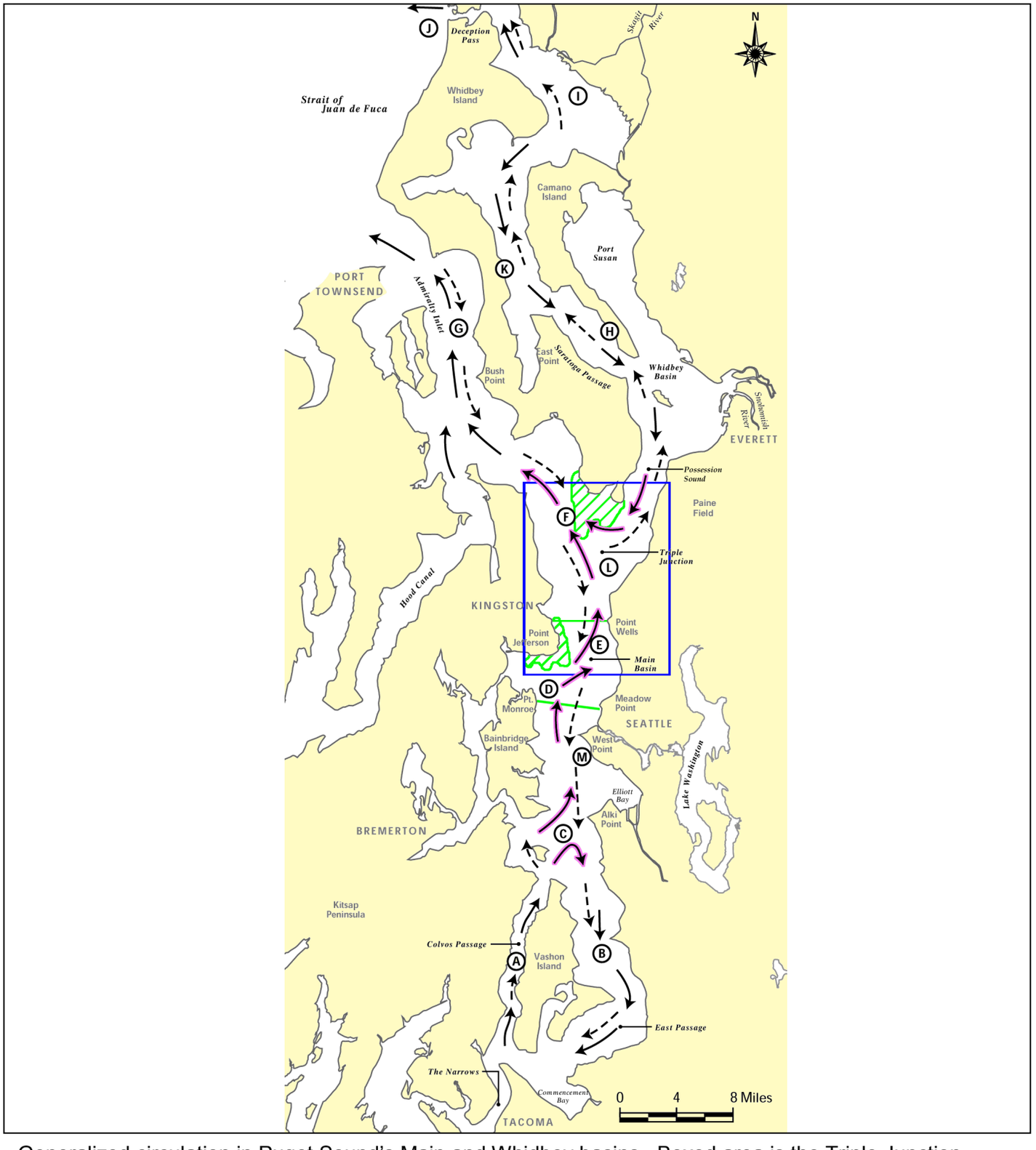
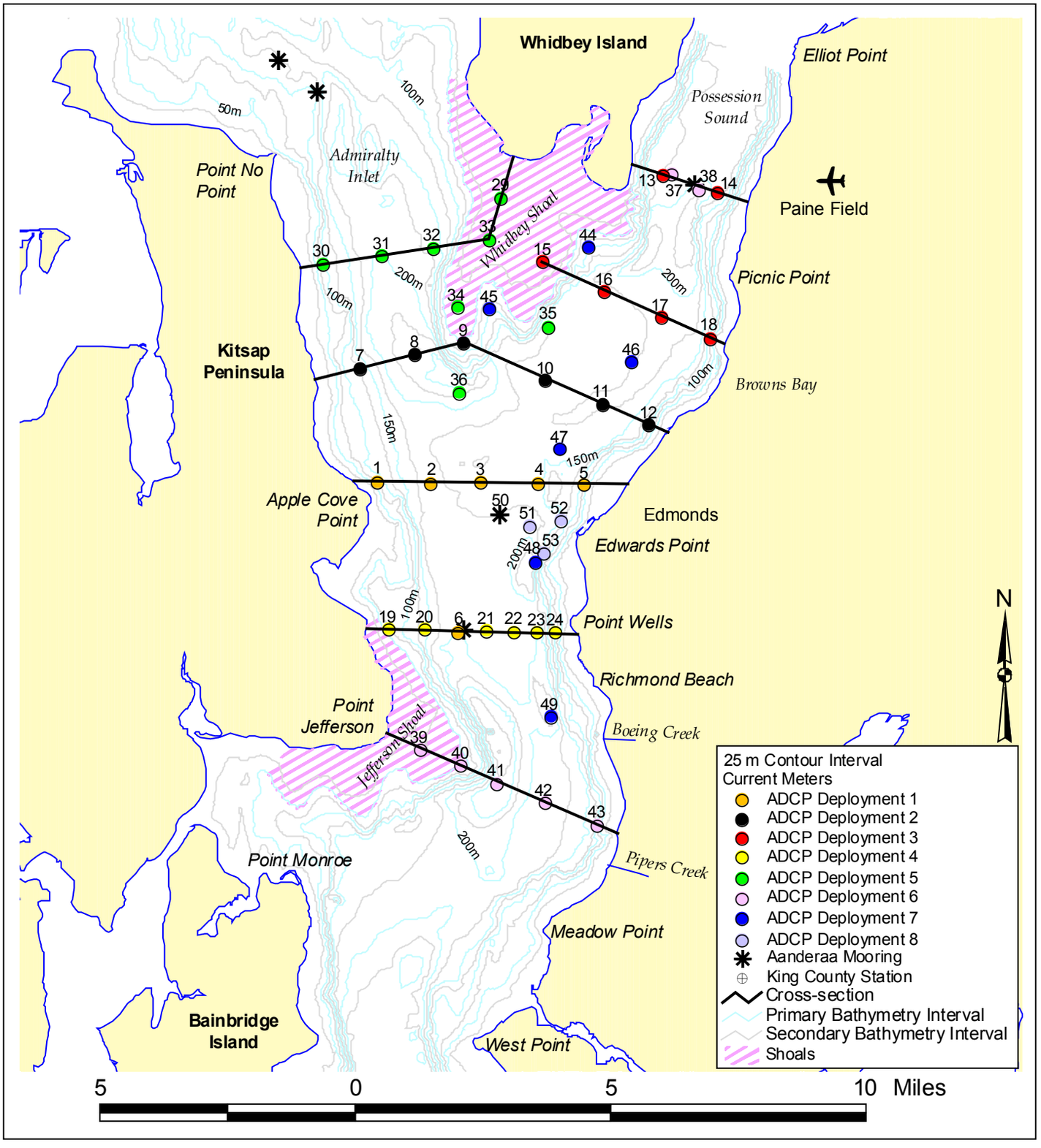
Figure 1. **Schematic circulation in Puget Sound**



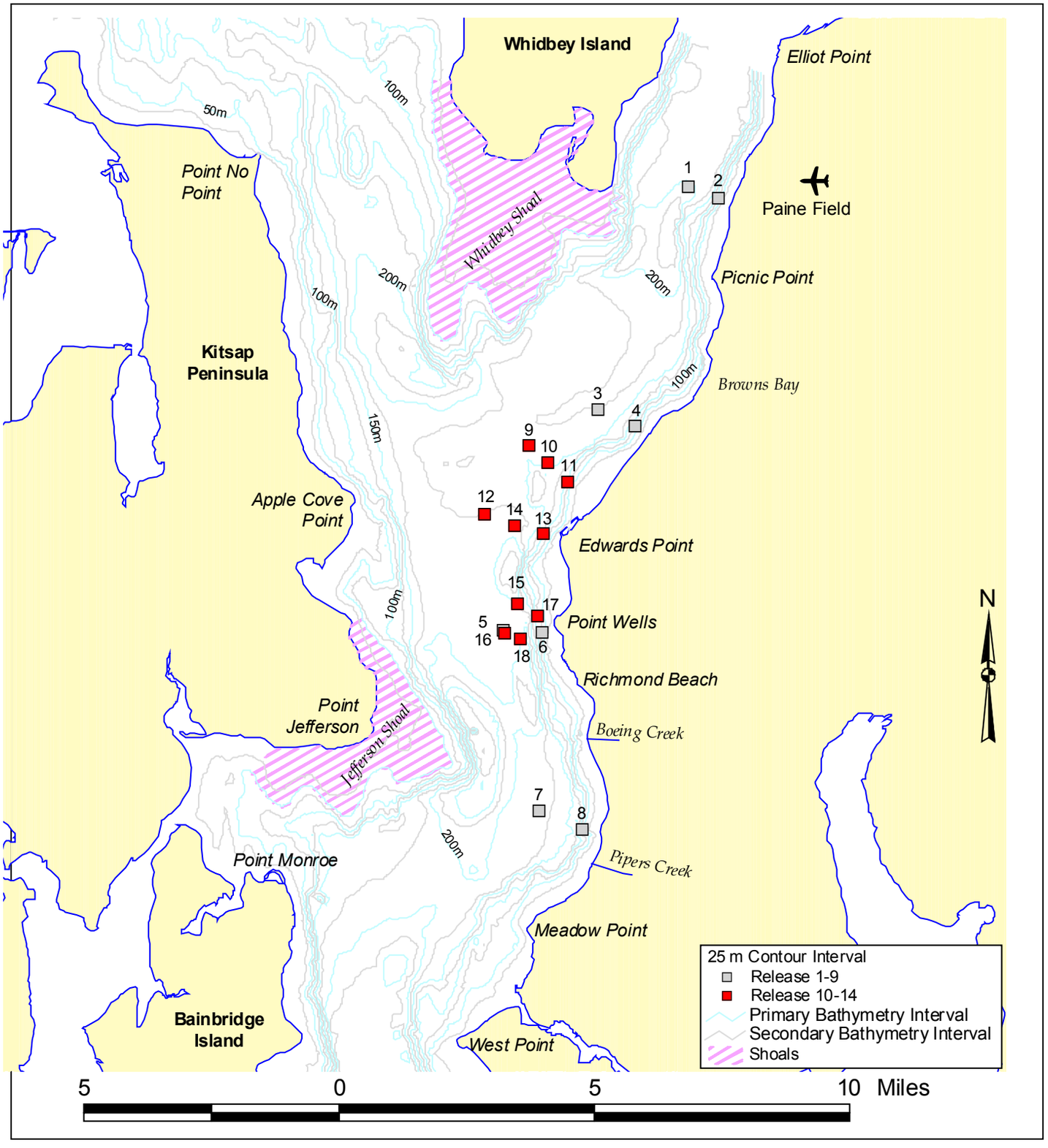
Generalized circulation in Puget Sound's Main and Whidbey basins. Boxed area is the Triple Junction region of this study. See text for explanations of features A–K. Solid vectors are surface flow; dashed, deep flow.

Figure 2. **Current meter mooring locations**



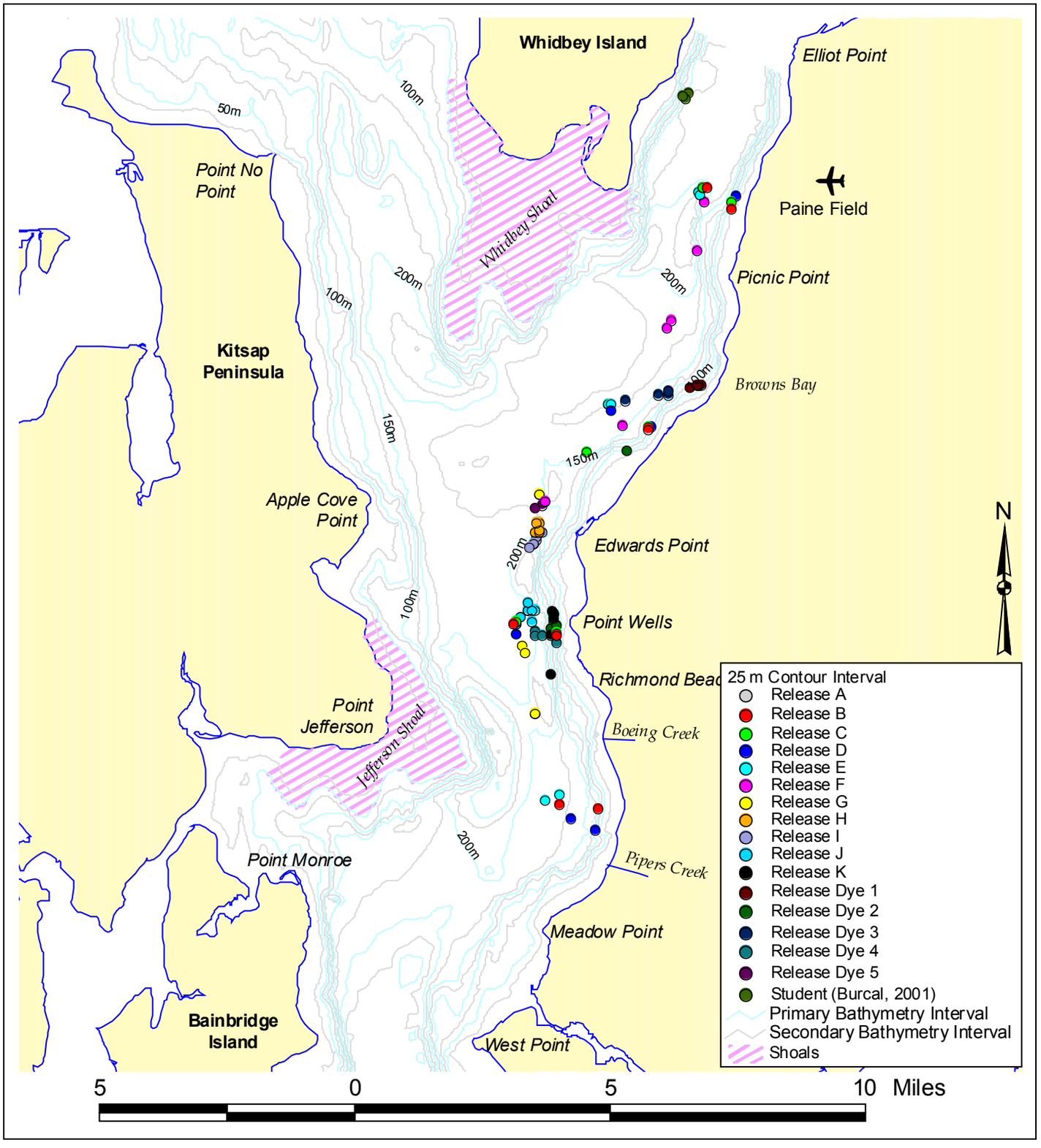
Current meter mooring arrays were deployed from July 2000 through January 2002. Each array is color coded and deployment dates are in Table 1. Lines connecting moorings indicate cross-channel sections where 28-day mean currents were calculated. Winds were observed at Paine Field. King County has obtained long-term water quality measurements at the site designated KSBP01. Bathymetric data were obtained from NOAA.

Figure 3. **Drift card deployment locations**



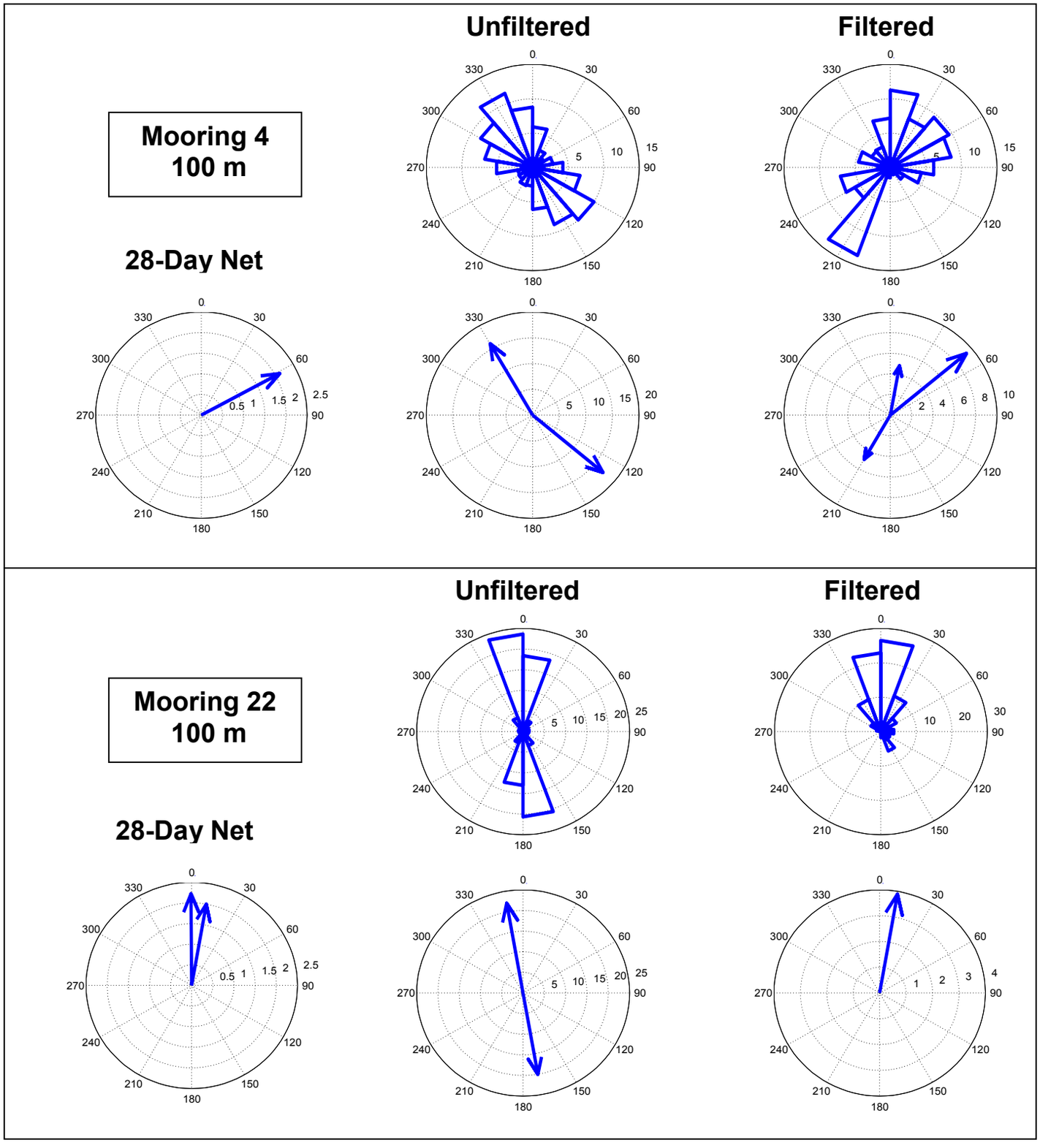
Releases 1-9 were at sites 1-8; releases 10-14 were at sites 9-18.

Figure 4. **Drogue release locations**



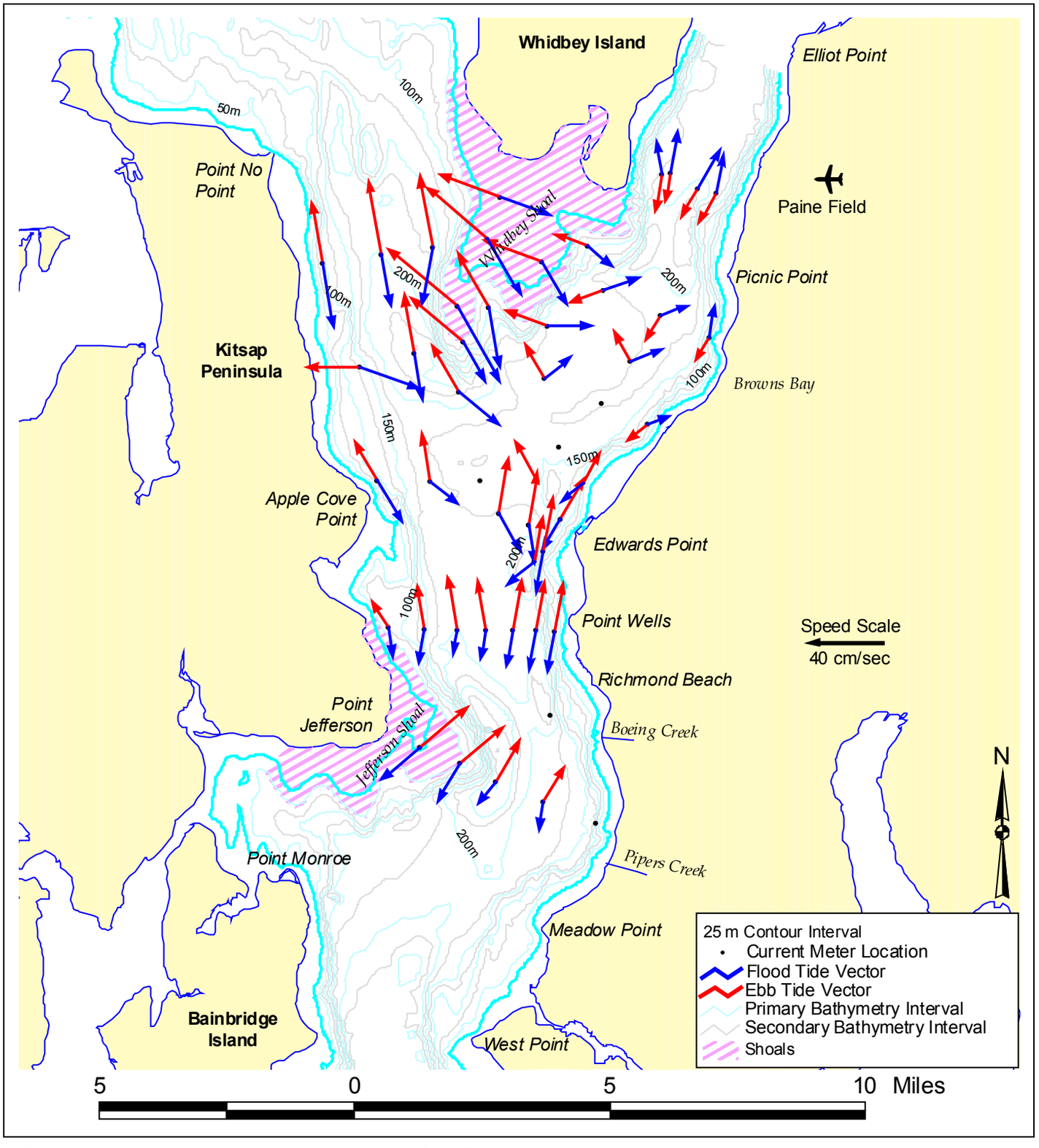
Drogues were deployed 18 times and tracked for 1-7 days (see Table 5). Release in Colvos Passage by Hoglund (2001) not shown.

Figure 5. **Histograms and modal current comparisons**



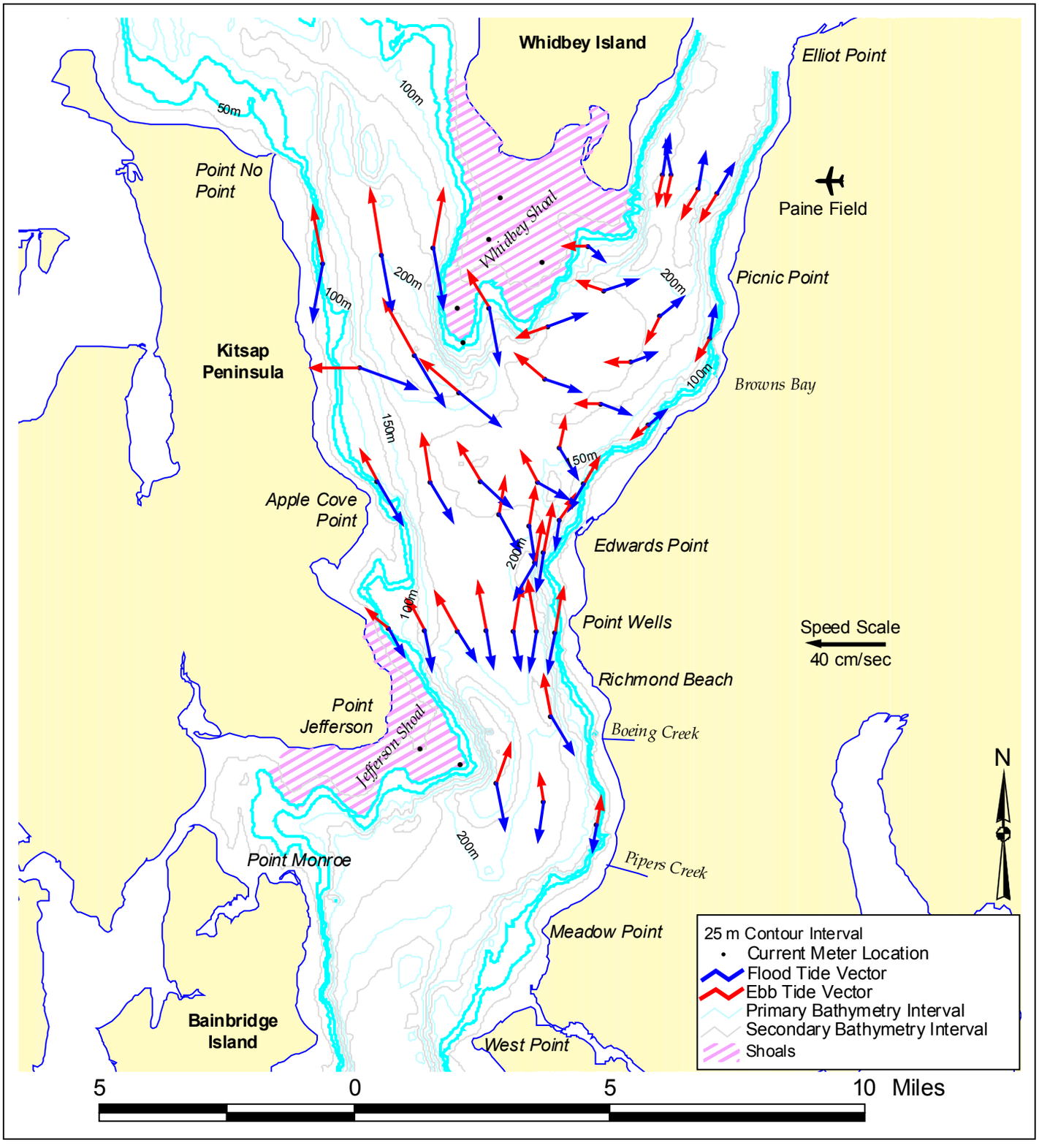
Currents at 100 m at moorings 4 (top) and 22 (bottom). In each, top are 20° histograms of current directions (current roses); bottom, mean currents in dominant 20° increments and mean vector currents. The left vectors are mean currents; middle pair are unfiltered data; and right pair are low-pass filtered currents.

Figure 6. **Tidal current modes: 20 m**



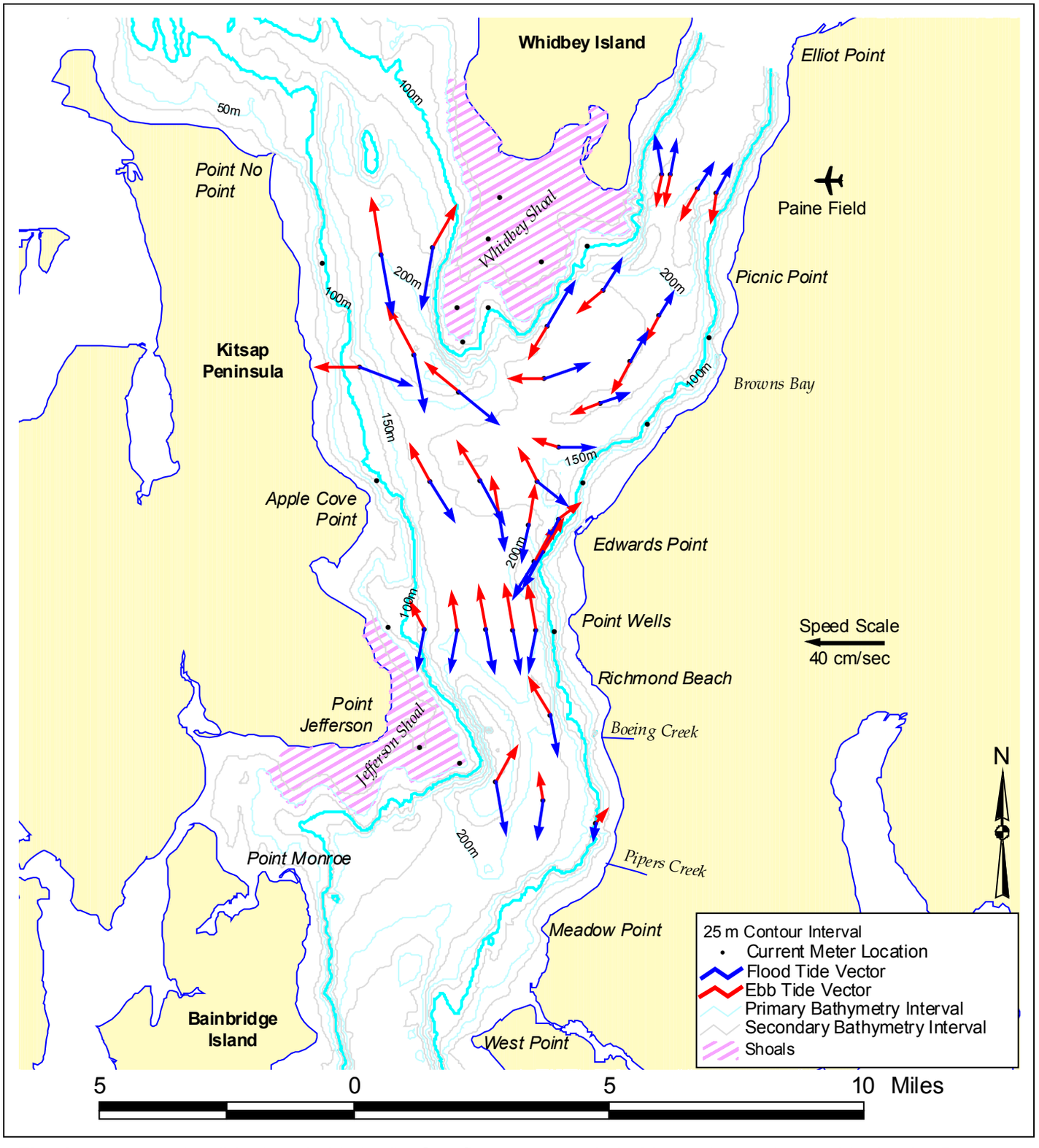
Flood current modes (blue) and ebb (red). Sea floor contours in bold equal or embrace this depth. Dots without arrows indicate insufficient data to determine tidal modes.

Figure 7. **Tidal current modes: 60 m**



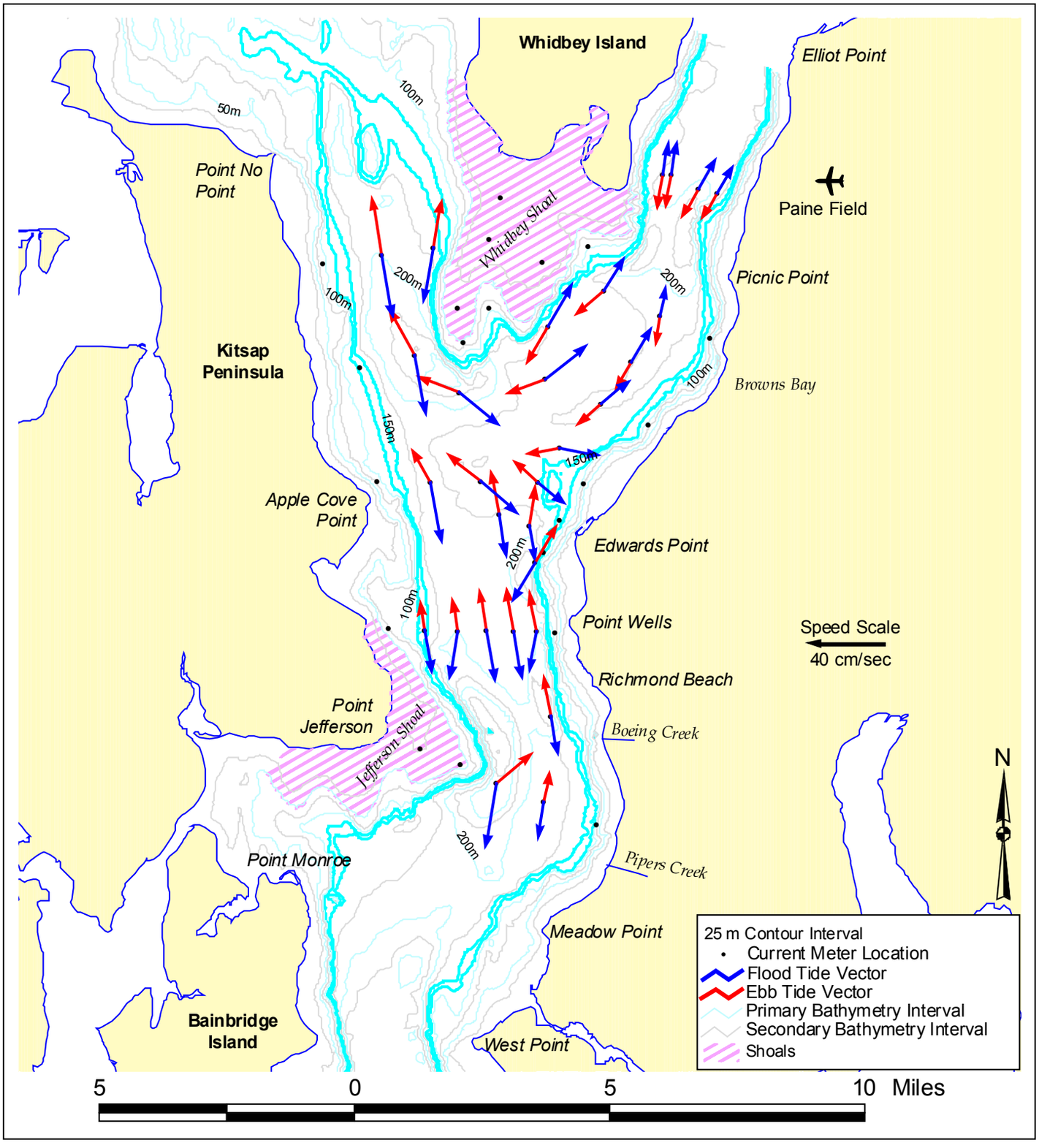
Flood current modes (blue) and ebb (red). Sea floor contours in bold equal or embrace this depth. Dots without arrows indicate stations with no data.

Figure 8. **Tidal current modes: 100 m**



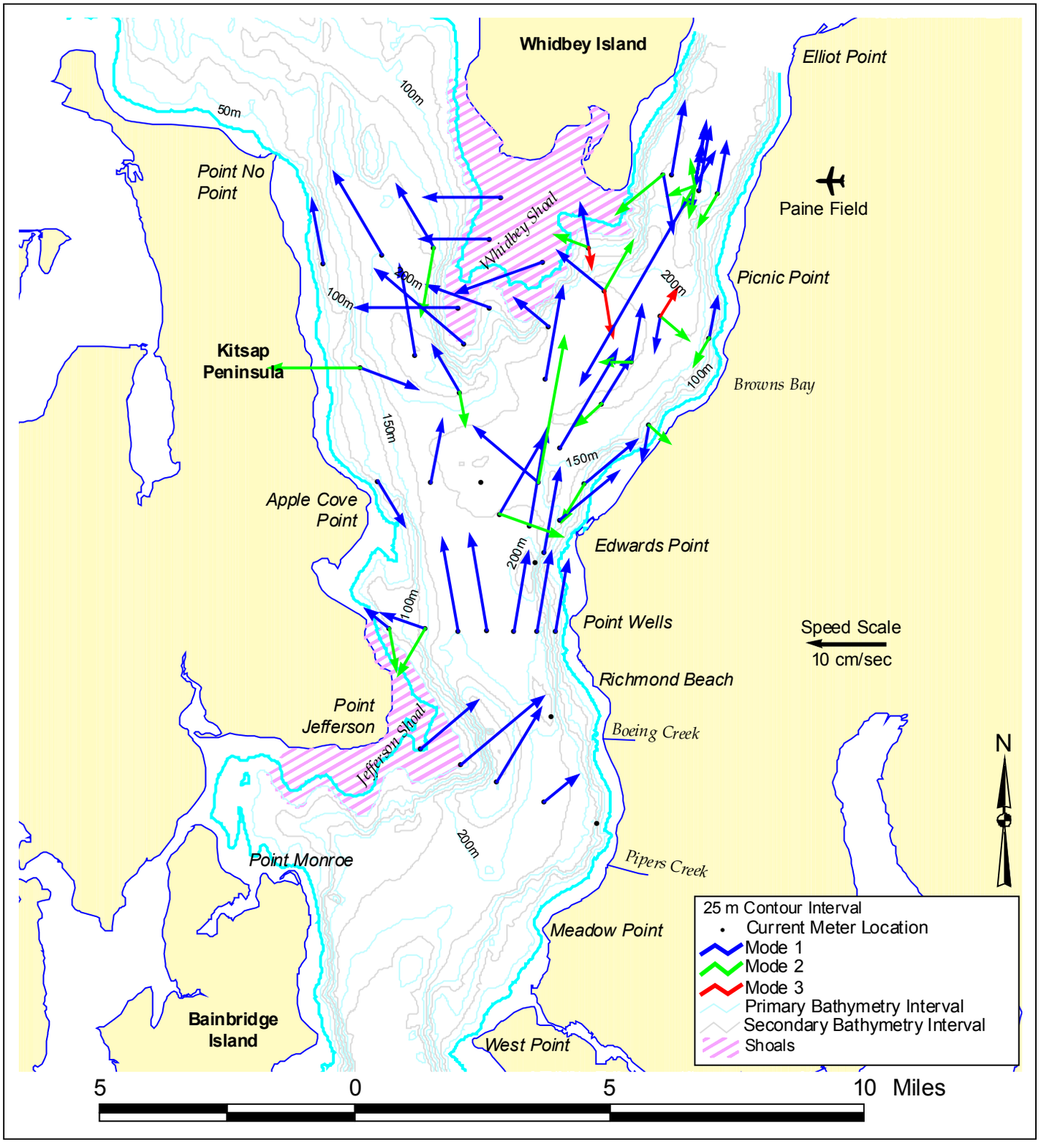
Flood current modes (blue) and ebb (red). Sea floor contours in bold equal or embrace this depth. Dots without arrows indicate stations with no data.

Figure 9. **Tidal current modes: 140 m**



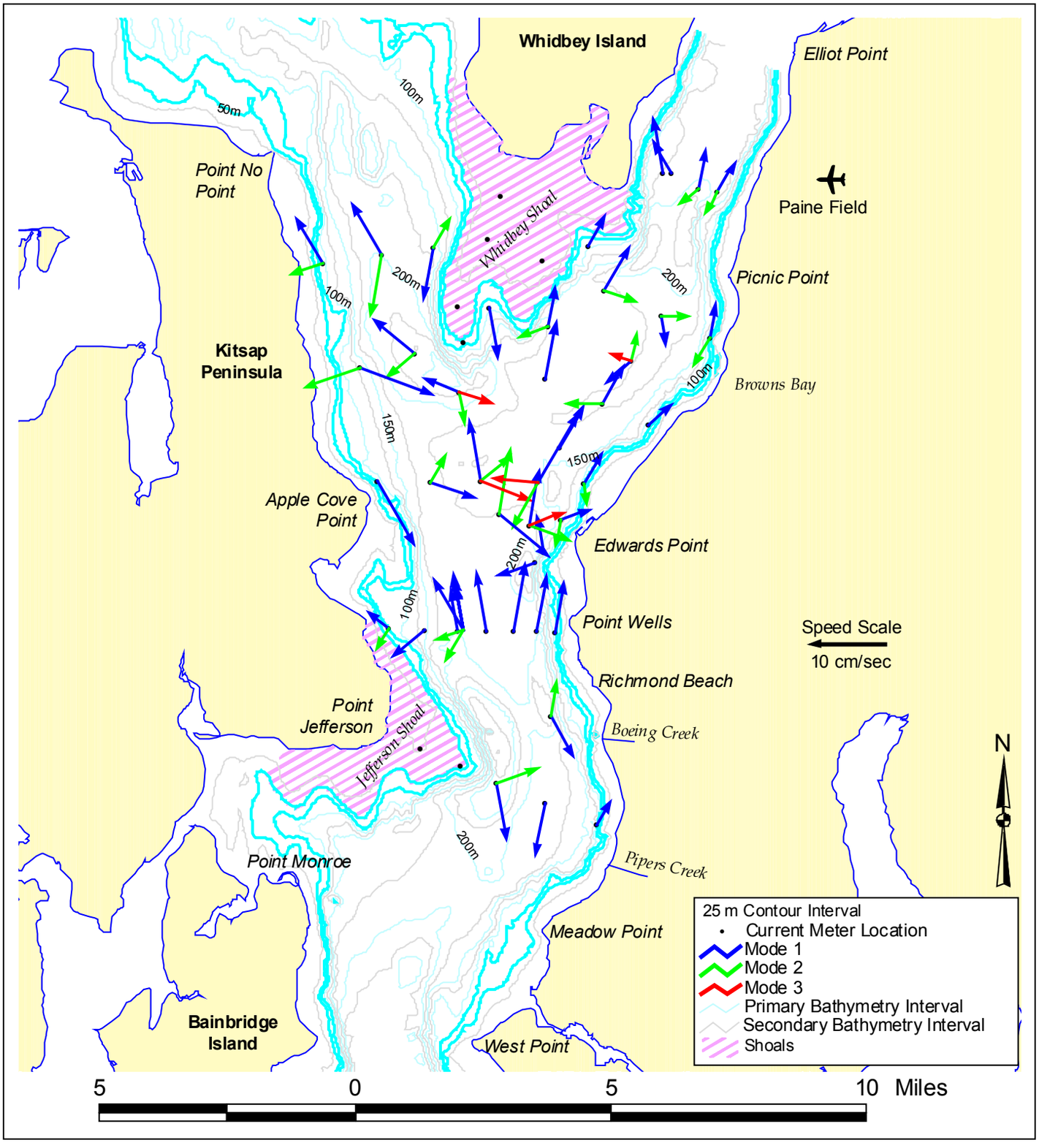
Flood current modes (blue) and ebb (red). Sea floor contours in bold equal or embrace this depth. Dots without arrows indicate stations with no data.

Figure 10. **Low-frequency modal currents: 20 m**



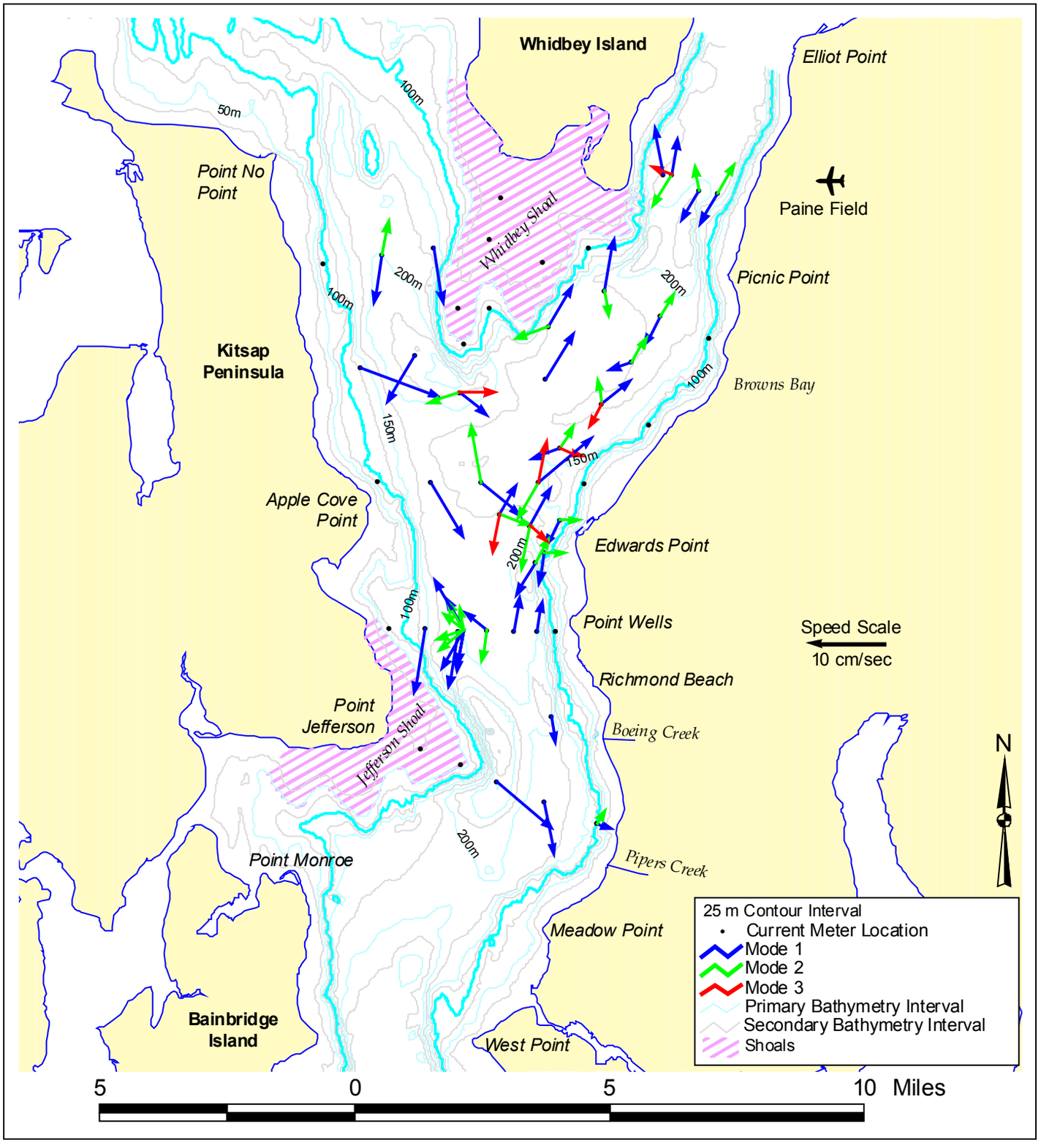
Mean currents in 20° histogram sectors. First mode (most frequent) is blue; second, green; and third, red. Filter was 35-hr Lanczos. Sea floor contours in bold equal or embrace this depth.

Figure 11. **Low-frequency modal currents: 60 m**



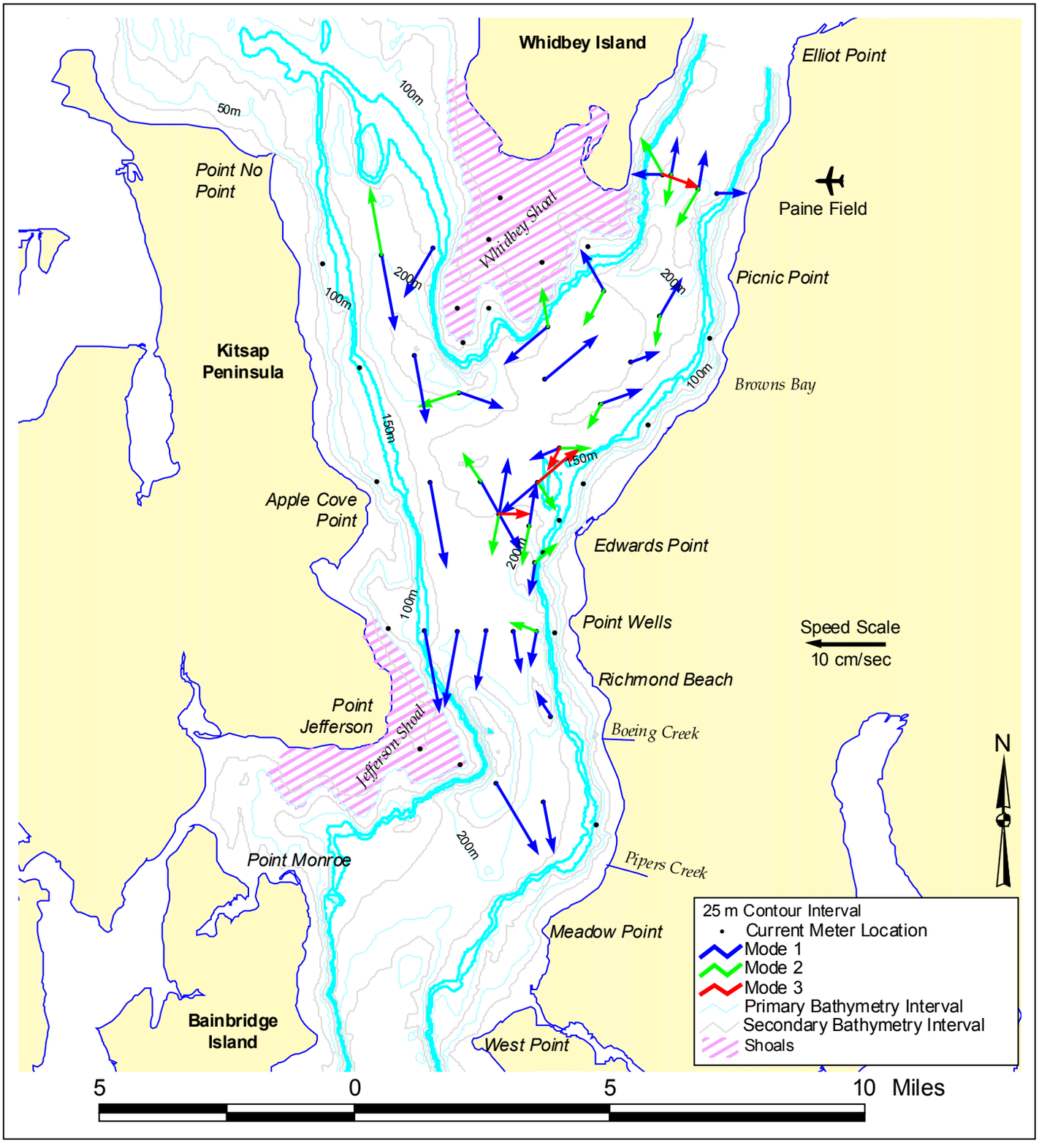
Mean currents in 20° histogram sectors. First mode (most frequent) is blue; second, green; and third, red. Filter was 35-hr Lanczos. Sea floor contours in bold equal or embrace this depth.

Figure 12. **Low-frequency modal currents: 100 m**



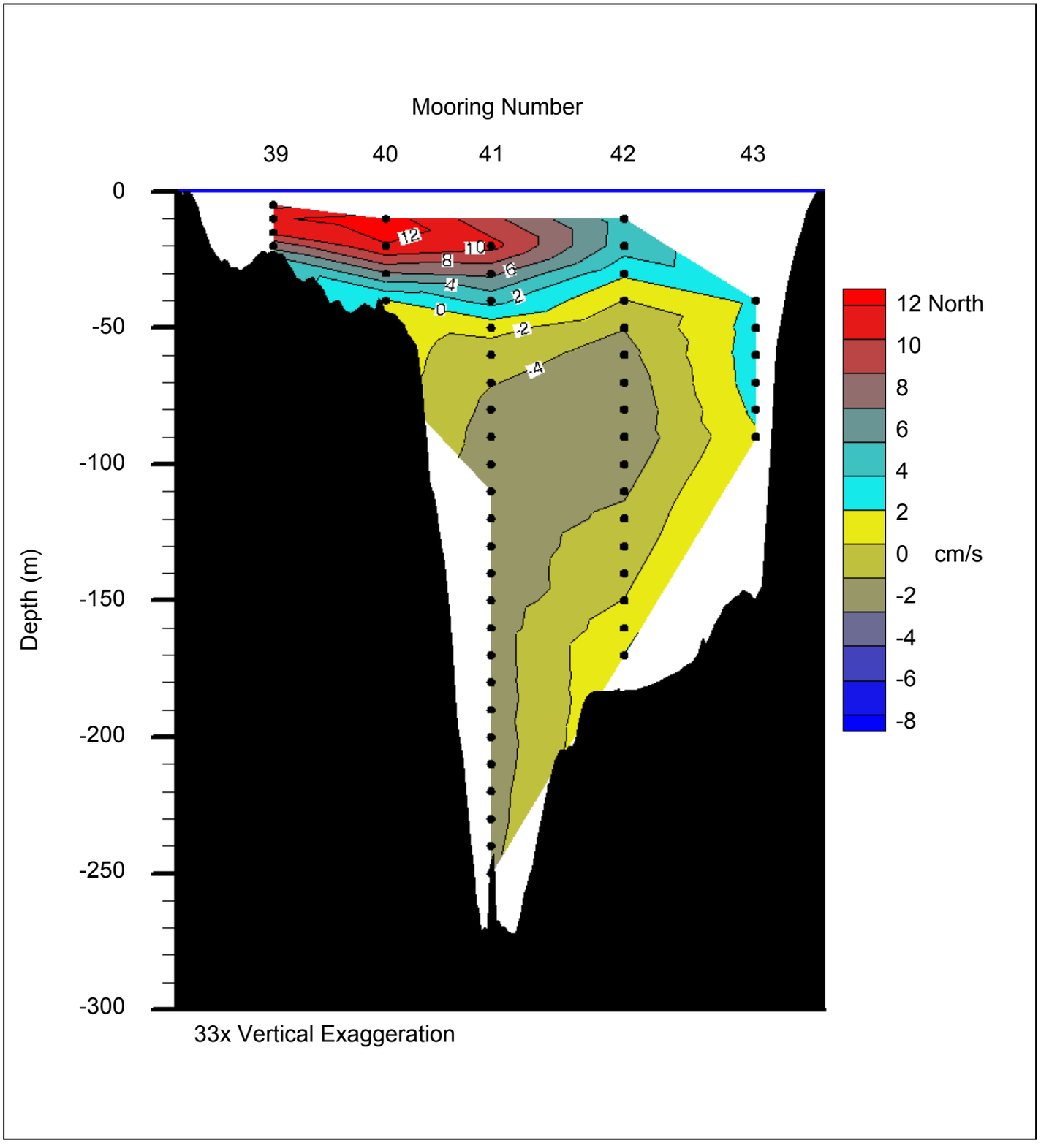
Mean currents in 20° histogram sectors. First mode (most frequent) is blue; second, green; and third, red. Filter was 35-hr Lanczos. Sea floor contours in bold equal or embrace this depth.

Figure 13. **Low-frequency modal currents: 140 m**



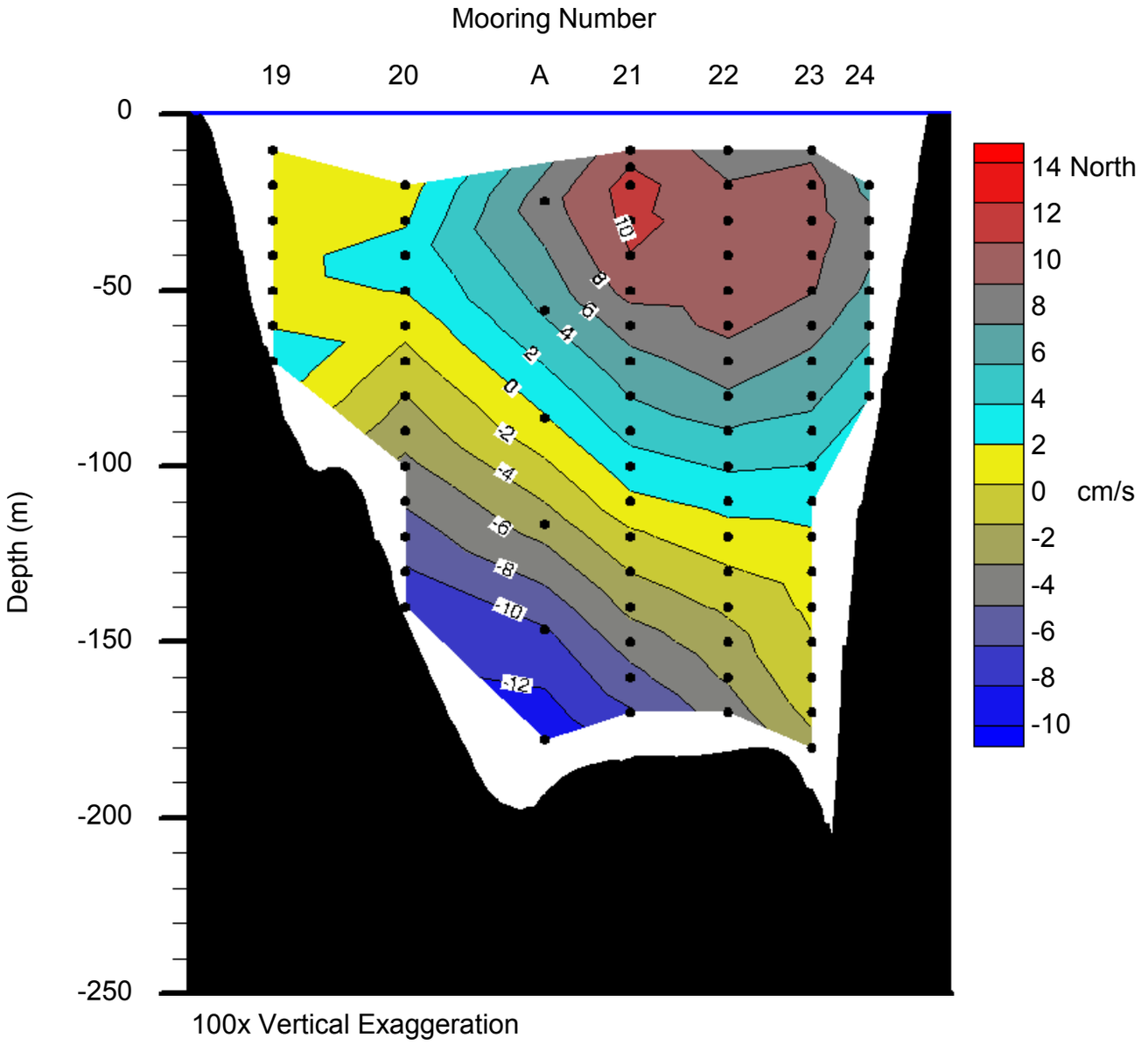
Mean currents in 20° histogram sectors. First mode (most frequent) is blue; second, green; and third, red. Filter was 35-hr Lanczos. Sea floor contours in bold equal or embrace this depth.

Figure 14. **Mean currents through the Point Jefferson section:**



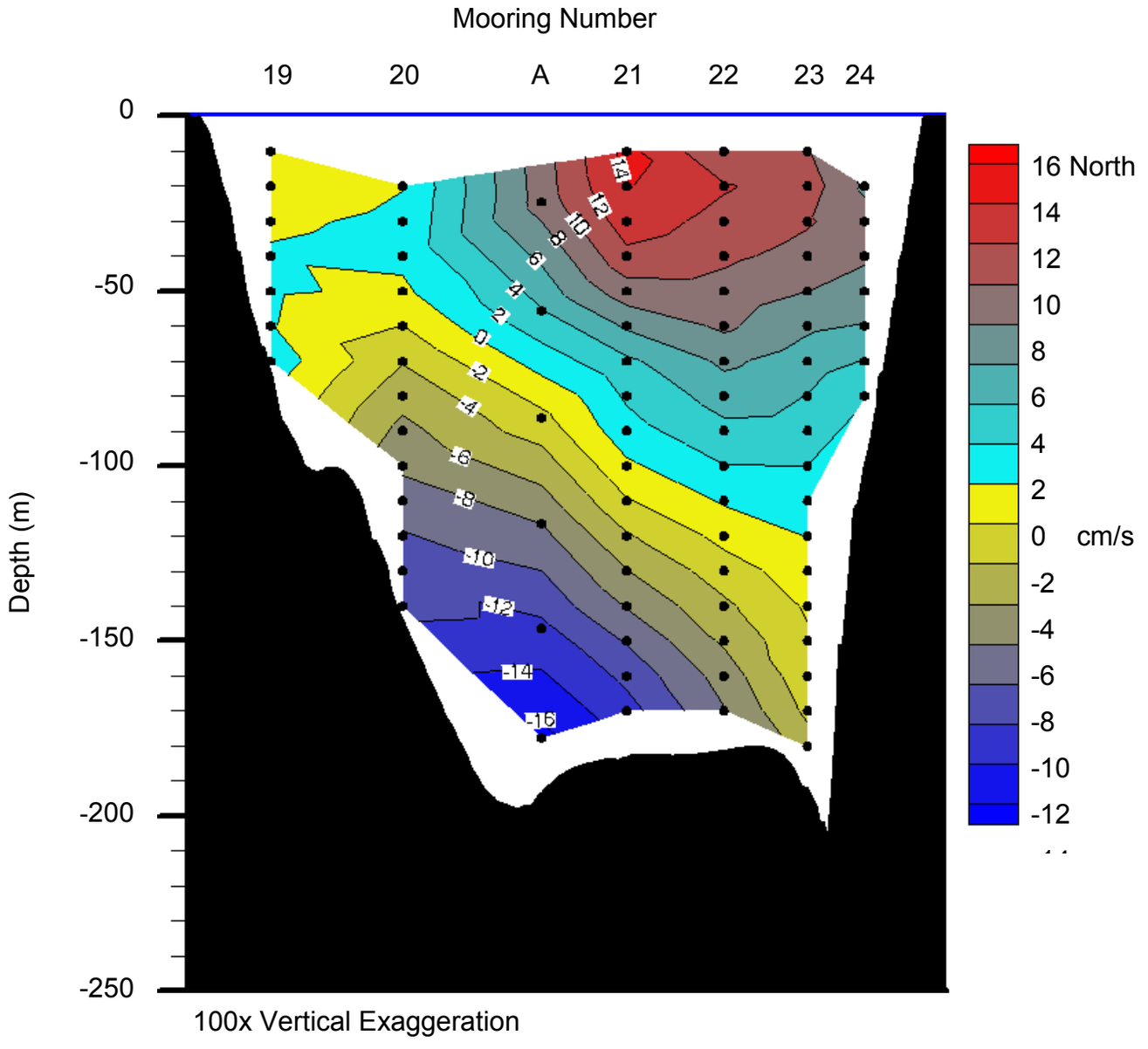
Mean currents perpendicular to the Point Jefferson section during Deployment 6 (D6; May 18 – June 14, 2001). Contour interval is 2 cm/s. Dots denote depths of 28-day means at ADCP moorings 39-43. See Figure 2 for locations.

Figure 15. **Mean currents through the Point Wells section:**



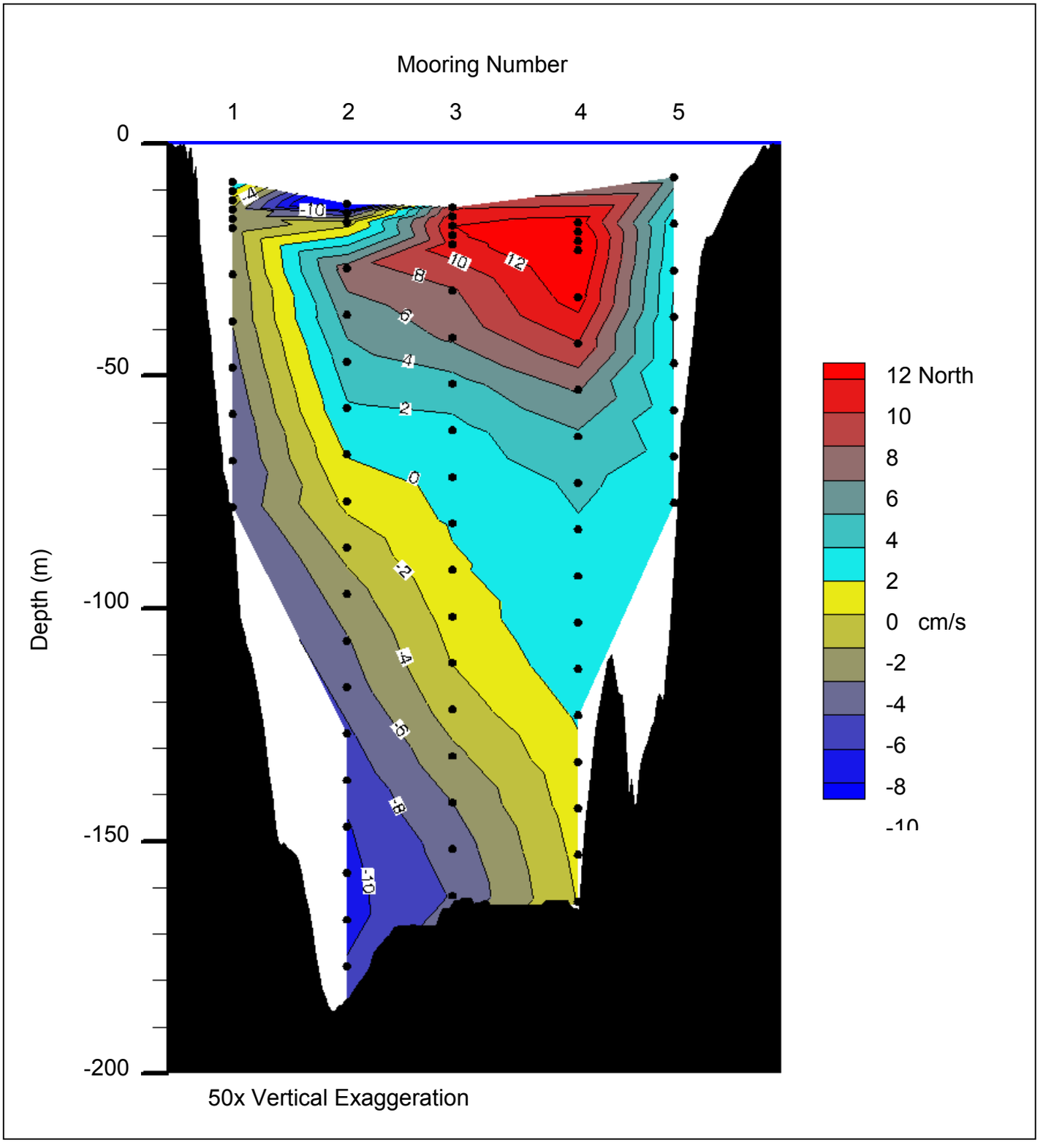
Mean currents perpendicular to the Point Wells section during Deployment 4 (D4a; January 27-February 23, 2001). Contour interval is 2 cm/s. Dots denote depths of 28-day means at ADCP moorings 19-24 and the Aanderaa mooring (A). See Figure 2 for locations.

Figure 16. **Mean currents through the Point Wells section:**



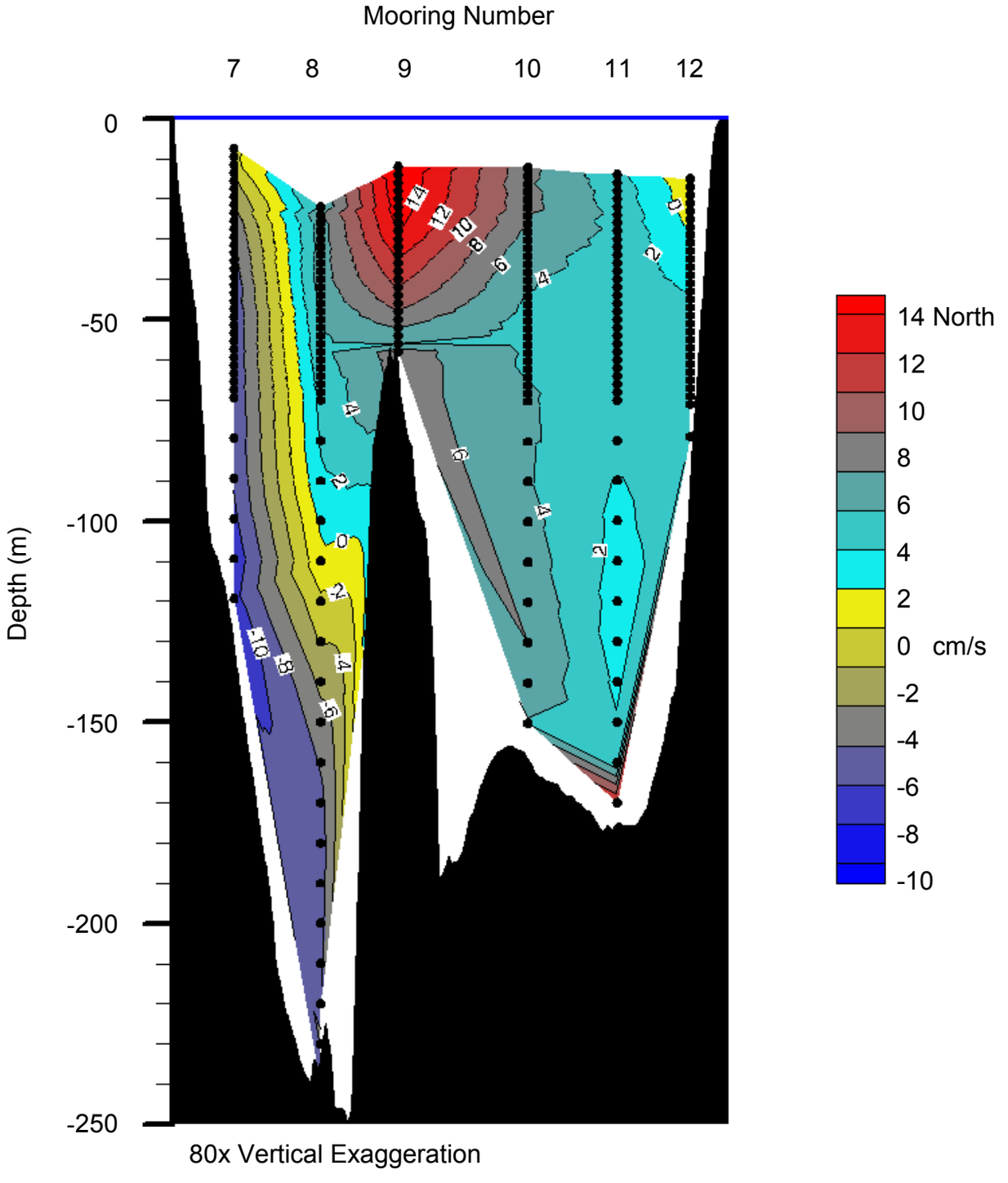
Mean currents perpendicular to the Point Wells section during Deployment 4 (D4b; February 20-March 20, 2001). Contour interval is 2 cm/s. Dots denote depths of 28-day means at ADCP moorings 19-24 and the Aanderaa mooring (A). See Figure 2 for locations.

Figure 17. **Mean currents through the Edwards Point section:**



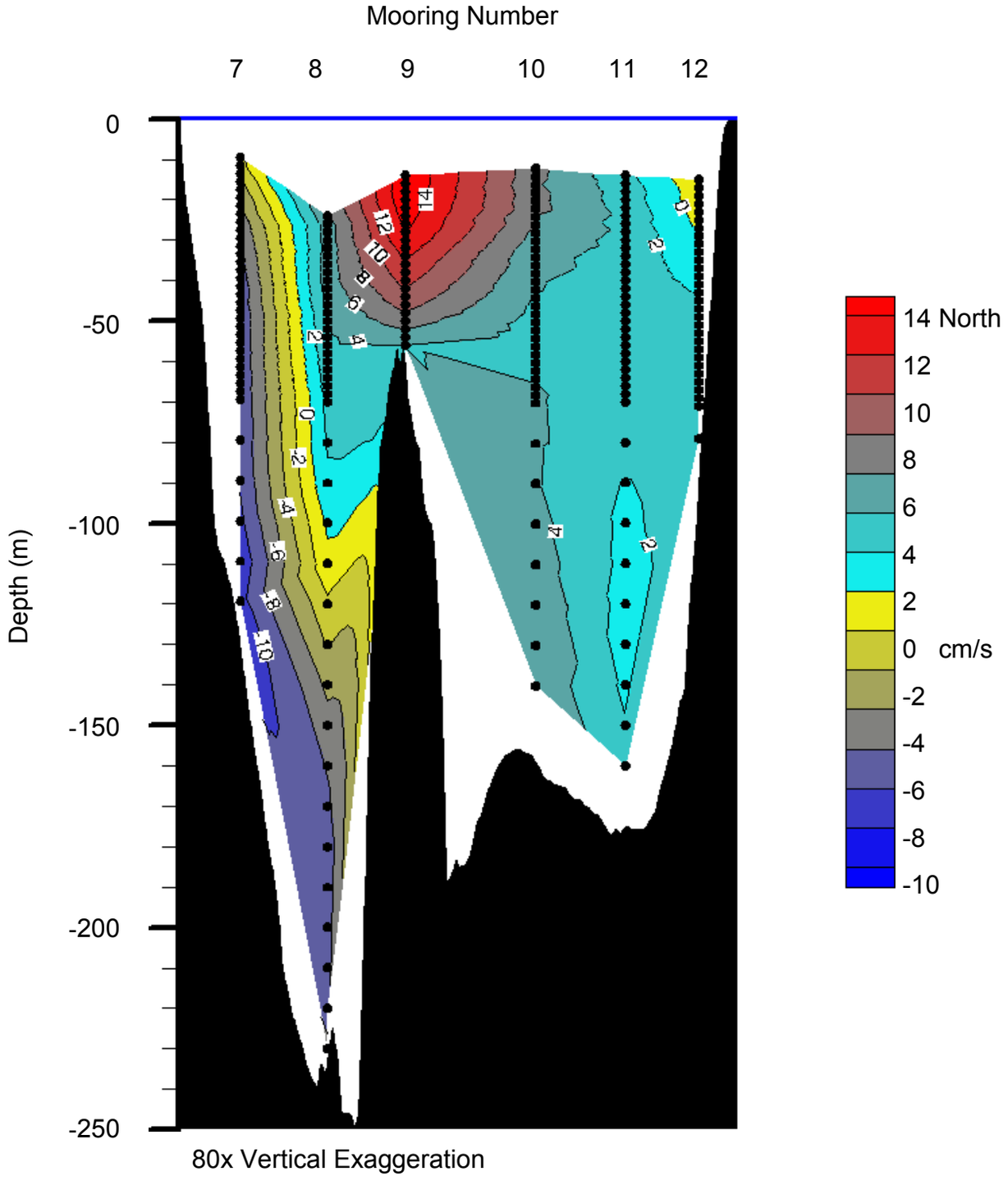
Mean currents perpendicular to the Edwards Point section during Deployment 1 (D1; July 14-August 10, 2000). Contour interval is 2 cm/s. Dots denote depths of 28-day means at ADCP moorings 1-5. See Figure 2 for locations.

Figure 18. **Mean Currents Through The Edmonds Section:**



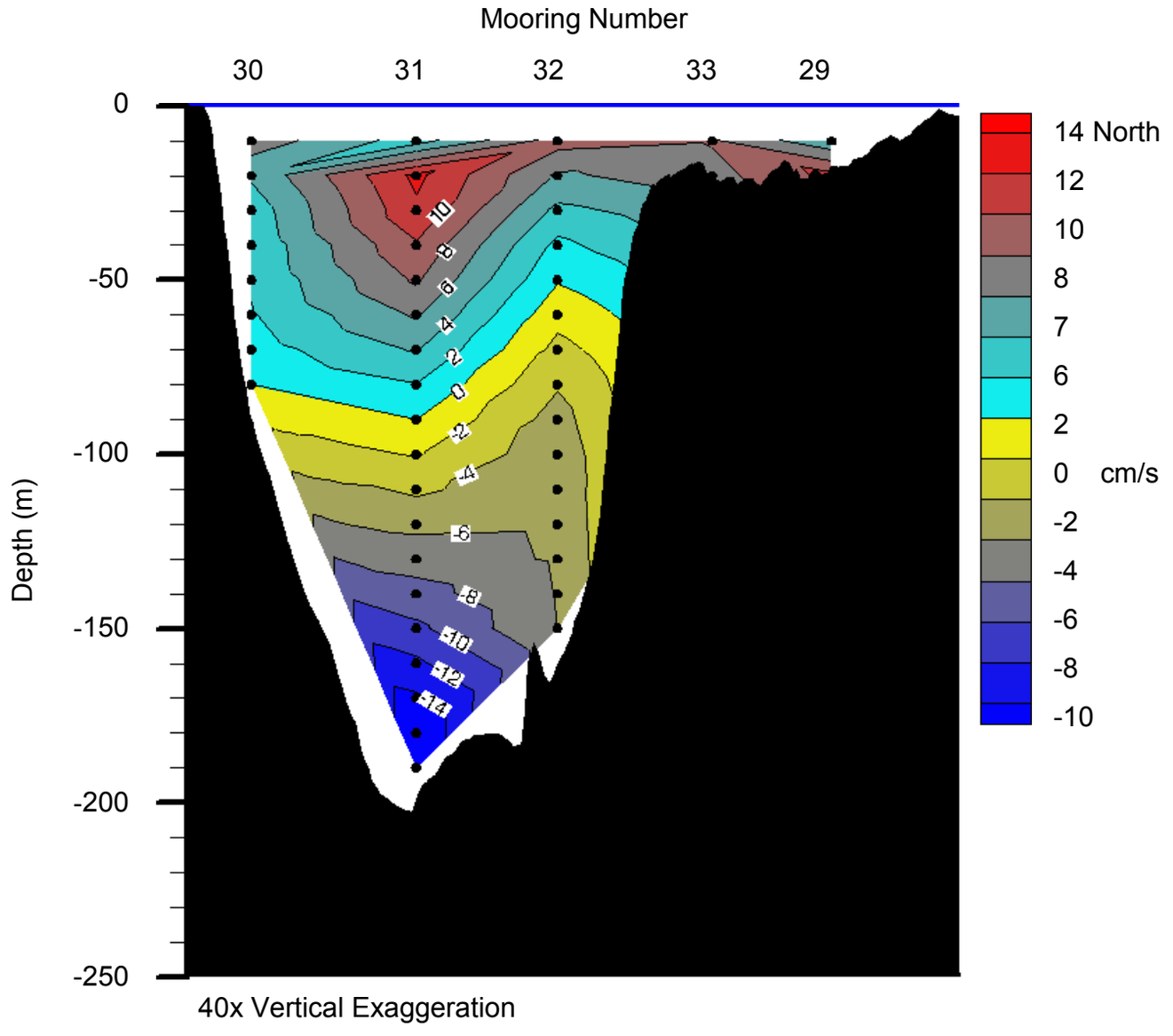
Mean currents perpendicular to the Edmonds section during Deployment 2 (D2a; August 22-September 21, 2000). Contour interval is 2 cm/s. Dots denote depths of 28-day means at ADCP moorings 7-12. See Figure 2 for locations. Currents at mooring 9 are perpendicular to the transect segment between moorings 7 and 9.

Figure 19. **Mean Currents Through The Edmonds Section:**



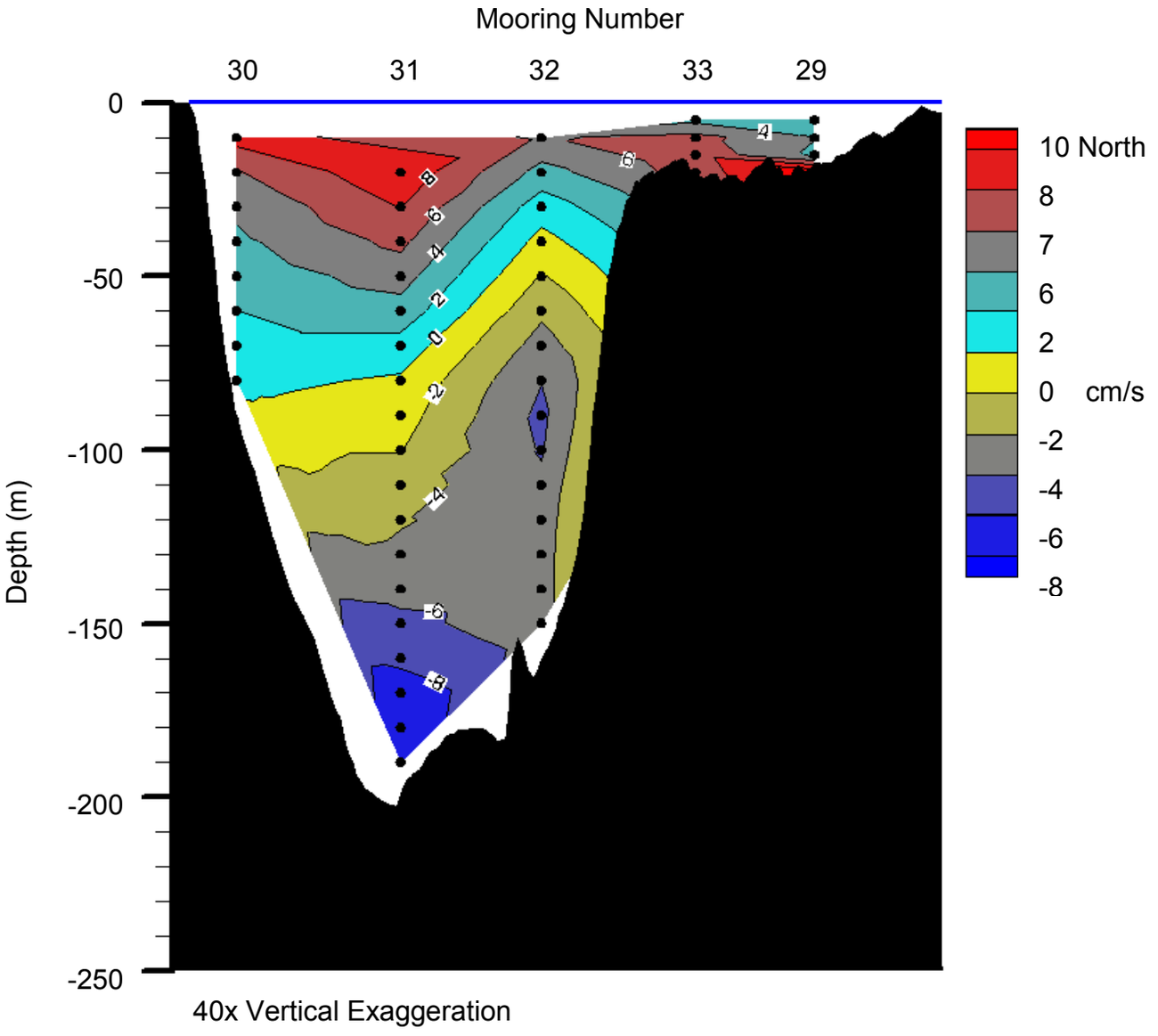
Mean currents perpendicular to the Edmonds section during Deployment 2 (D2b; October 1-28, 2000). Contour interval is 2 cm/s. Dots denote depths of 28-day means at ADCP moorings 7-12. See Figure 2 for locations. Currents at mooring 9 are perpendicular to the transect segment between moorings 7 and 9.

Figure 20. **Mean currents through the Admiralty Inlet section:**



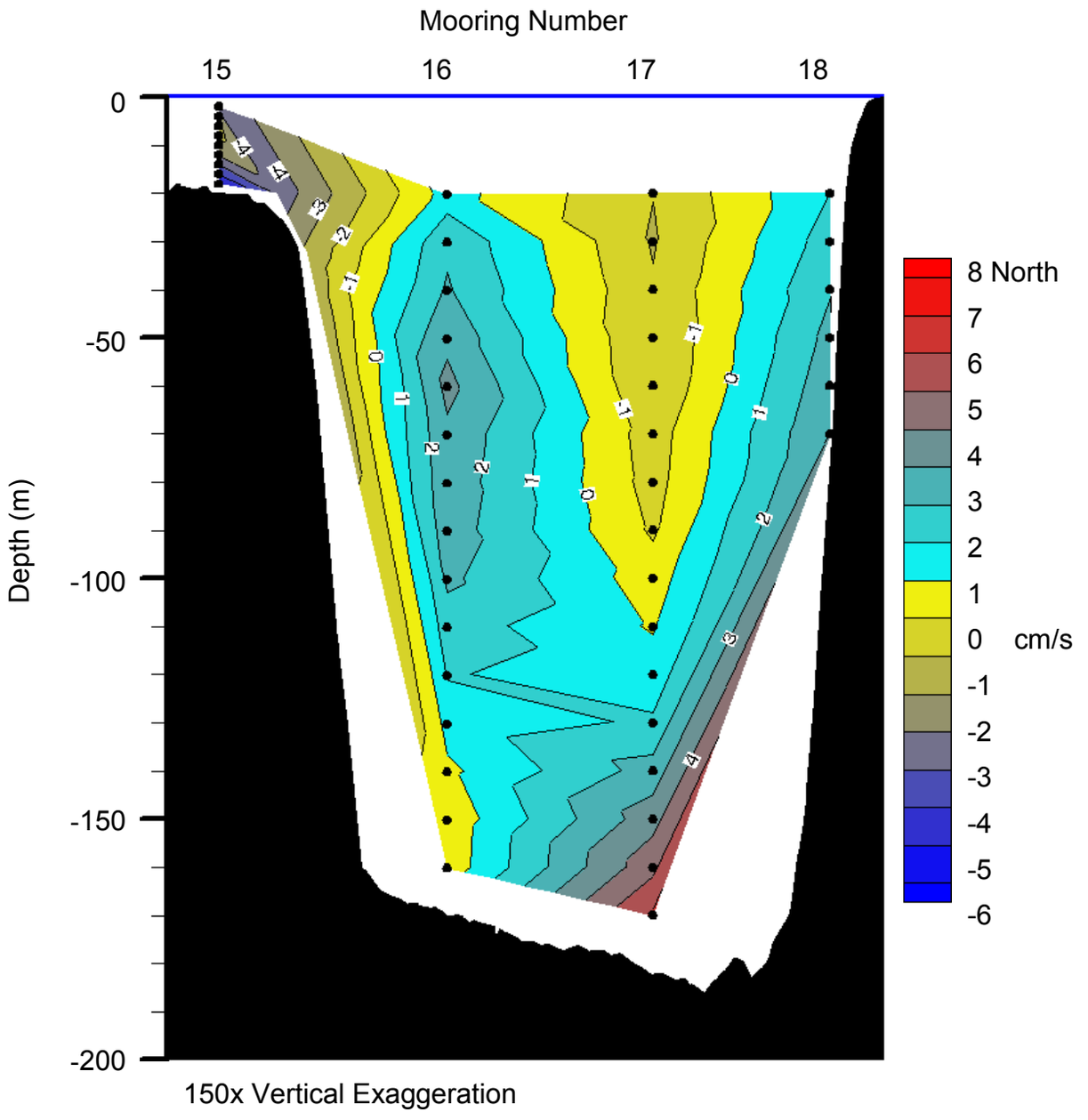
Mean currents perpendicular to the Admiralty Inlet section during Deployment 5 (D5a; March 24-April 20, 2001). Currents at Mooring 33 (at the corner where the section turns) are normal to the section between Moorings 29 and 33). Contour interval is 2 cm/s. Dots denote depths of 28-day means at ADCP moorings 30-33, and 29. See Figure 2 for locations.

Figure 21. **Mean currents through the Admiralty Inlet section:**



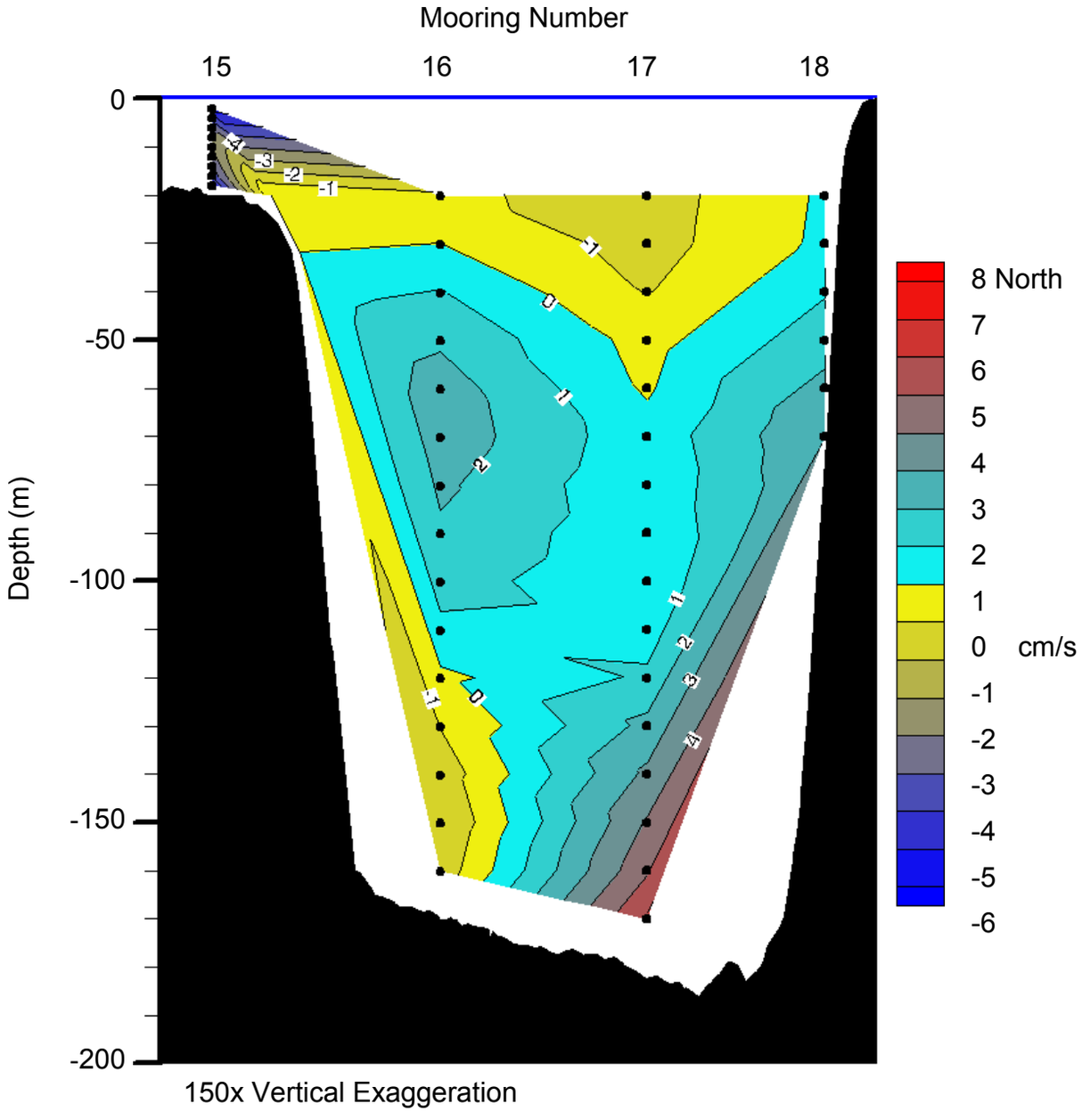
Mean currents perpendicular to the Admiralty Inlet section during Deployment 5 (D5b; April 16-May 13, 2001). Currents at Mooring 33 (at the corner where the section turns) are normal to the section between Moorings 29 and 33). Contour interval is 2 cm/s. Dots denote depths of 28-day means at ADCP moorings 30-33, and 29. See Figure 2 for locations.

Figure 22. **Mean Currents Through the Browns Bay Section:**



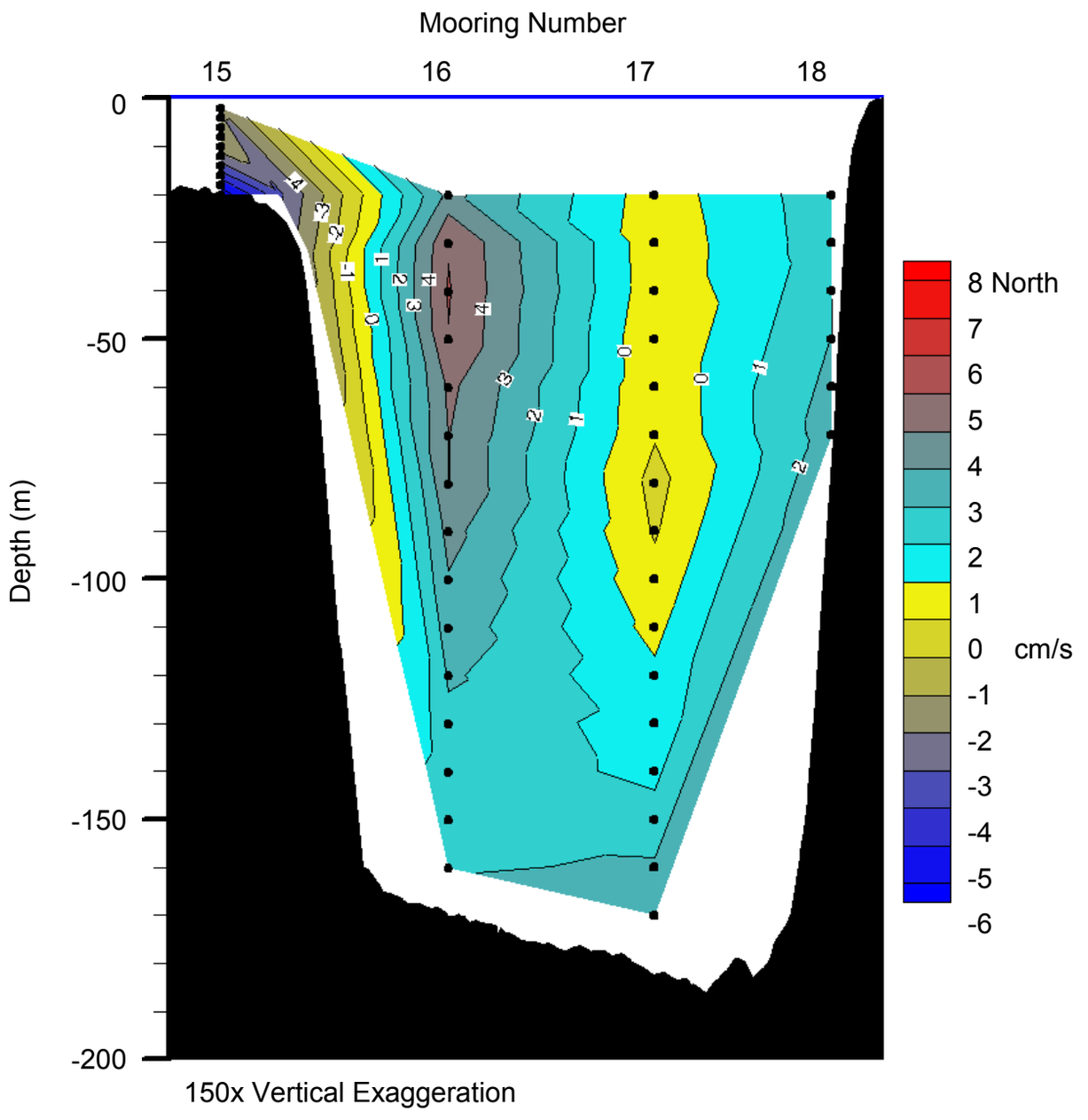
Mean currents perpendicular to the Browns Bay section during Deployment 3 (D3a; November 3-30, 2000). Contour interval is 1 cm/s. Dots denote depths of 28-day means at ADCP moorings 15-18. See Figure 2 for locations.

Figure 23. **Mean Currents Through the Browns Bay Section:**



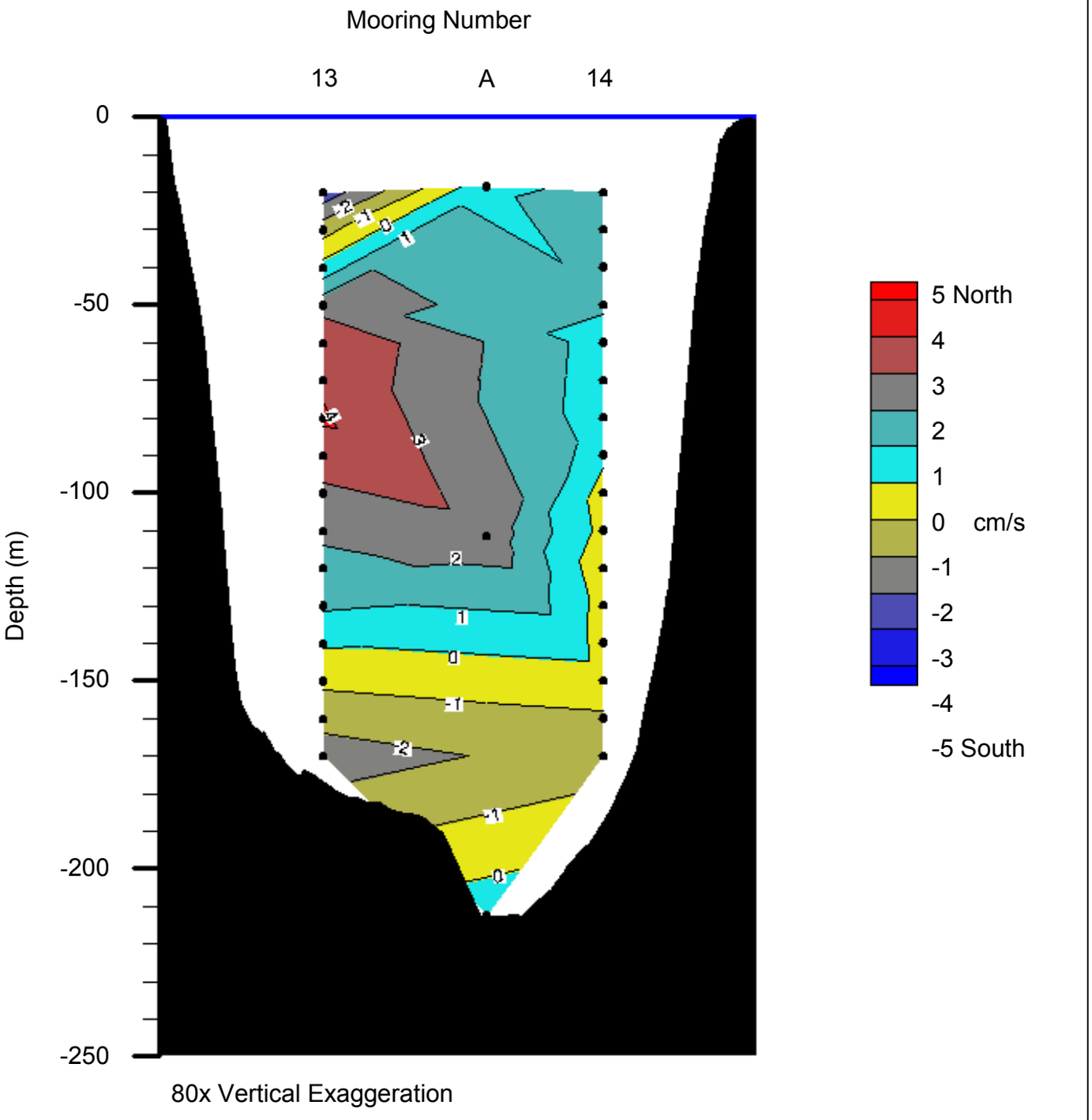
Mean currents perpendicular to the Browns Bay section during Deployment 3 (D3b; December 1-28, 2000). Contour interval is 1 cm/s. Dots denote depths of 28-day means at ADCP moorings 15-18. See Figure 2 for locations.

Figure 24. **Mean Currents Through the Browns Bay Section:**



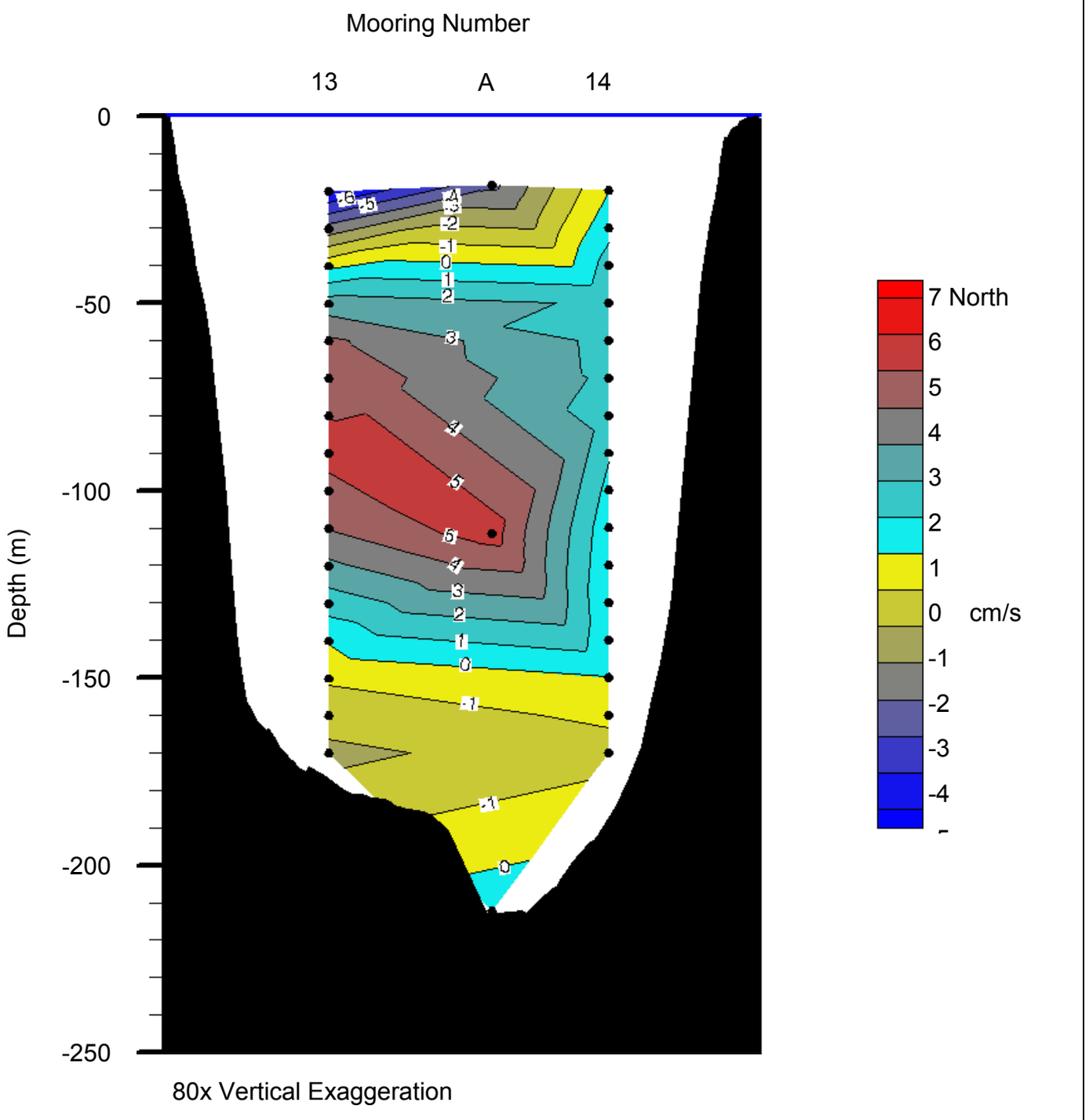
Mean currents perpendicular to the Browns Bay section during Deployment 3 (D3c; December 27, 2000-January 22, 2001). Contour interval is 1 cm/s. Dots denote depths of 28-day means at ADCP moorings 15-18. See Figure 2 for locations.

Figure 25. **Mean currents through the Possession Sound section:**



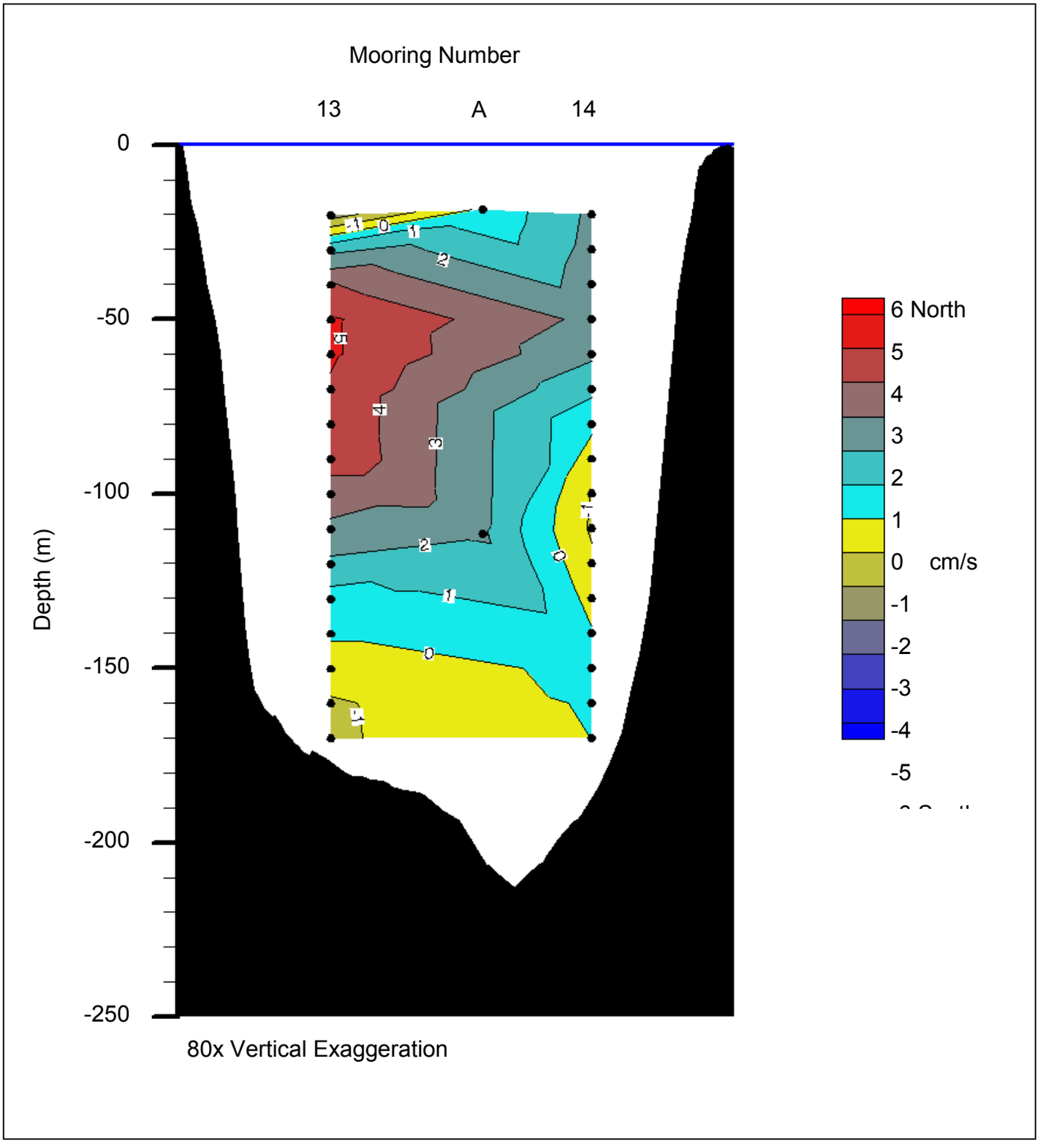
Mean currents perpendicular to the Possession Sound cross section during Deployment 3 (D3a; November 3-30, 2000). Contour interval is 1 cm/s. Dots denote depths of 28-day means at ADCP moorings 13-14 and the Aanderaa mooring (A). See Figure 2 for locations.

Figure 26. **Mean currents through the Possession Sound section:**



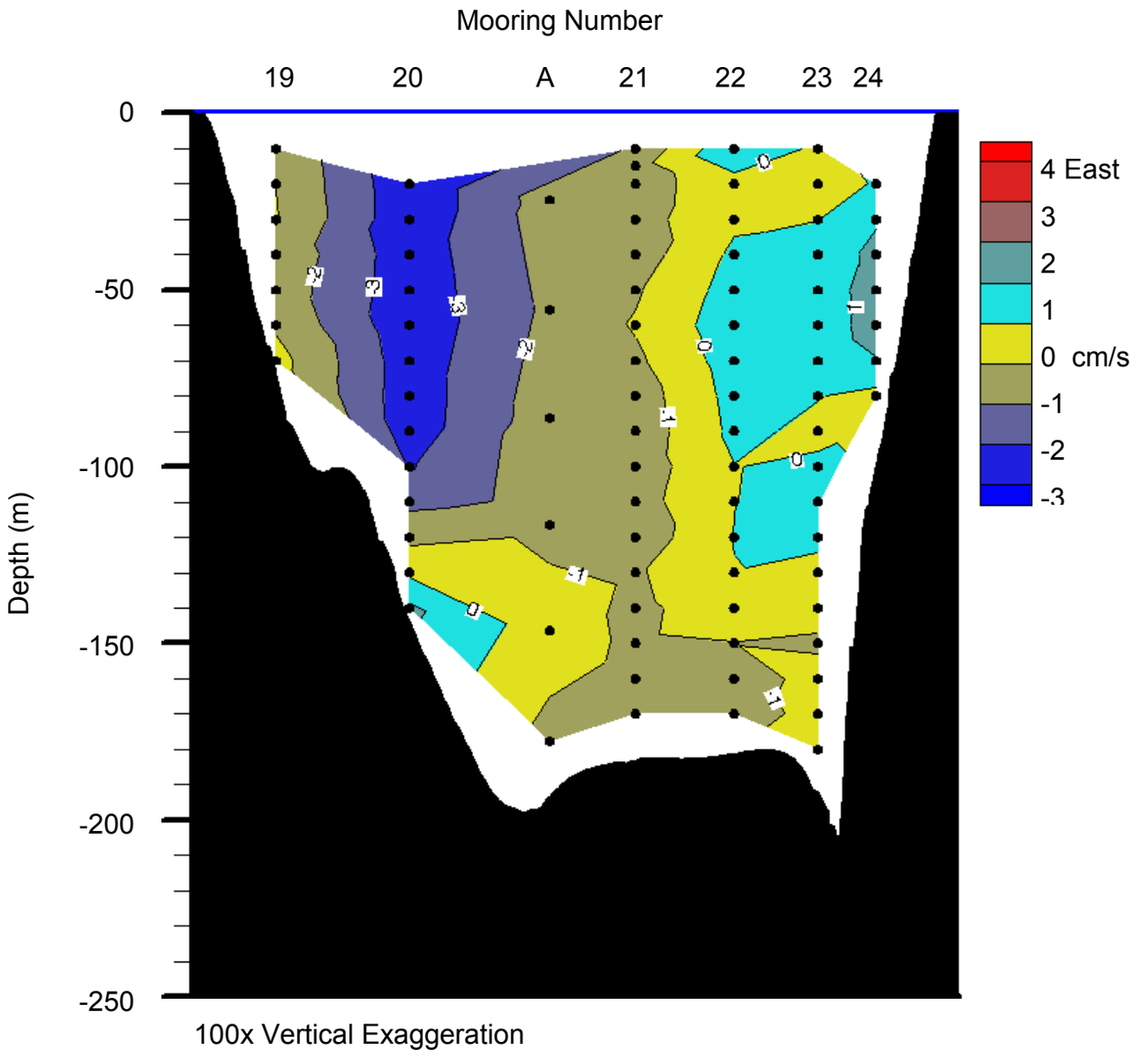
Mean currents perpendicular to the Possession Sound cross section during Deployment 3 (D3b; December 1-28, 2000). Contour interval is 1 cm/s. Dots denote depths of 28-day means at ADCP moorings 13-14 and the Aanderaa mooring (A). See Figure 2 for locations.

Figure 27. **Mean currents through the Possession Sound section:**



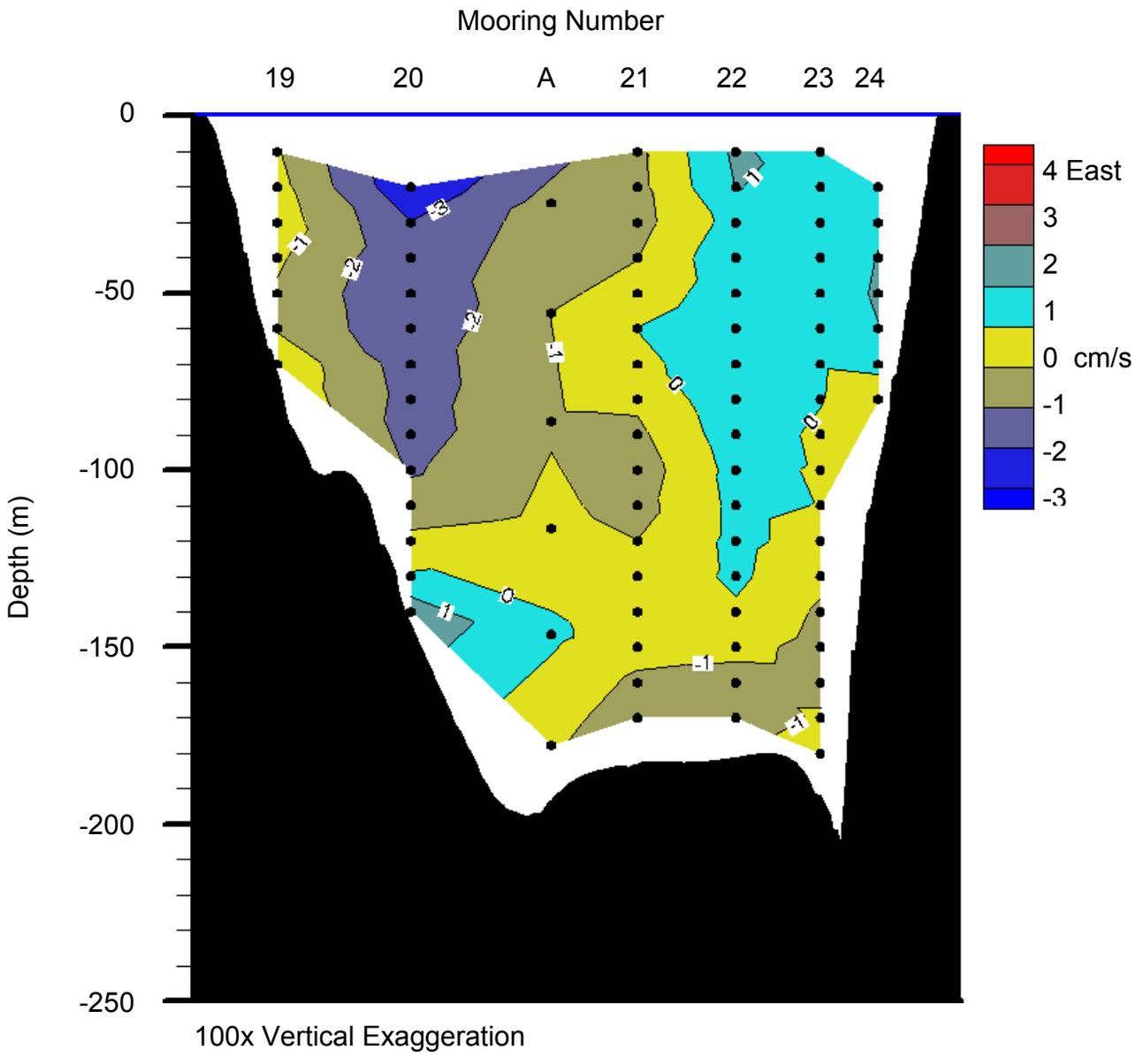
Mean currents perpendicular to the Possession Sound cross section during Deployment 3 (D3c; December 27, 2000-January 22, 2001). Contour interval is 1 cm/s. Dots denote depths of 28-day means at ADCP moorings 13-14 and the Aanderaa mooring (A). See Figure 2 for locations.

Figure 28. **Mean currents across the Point Wells section:**



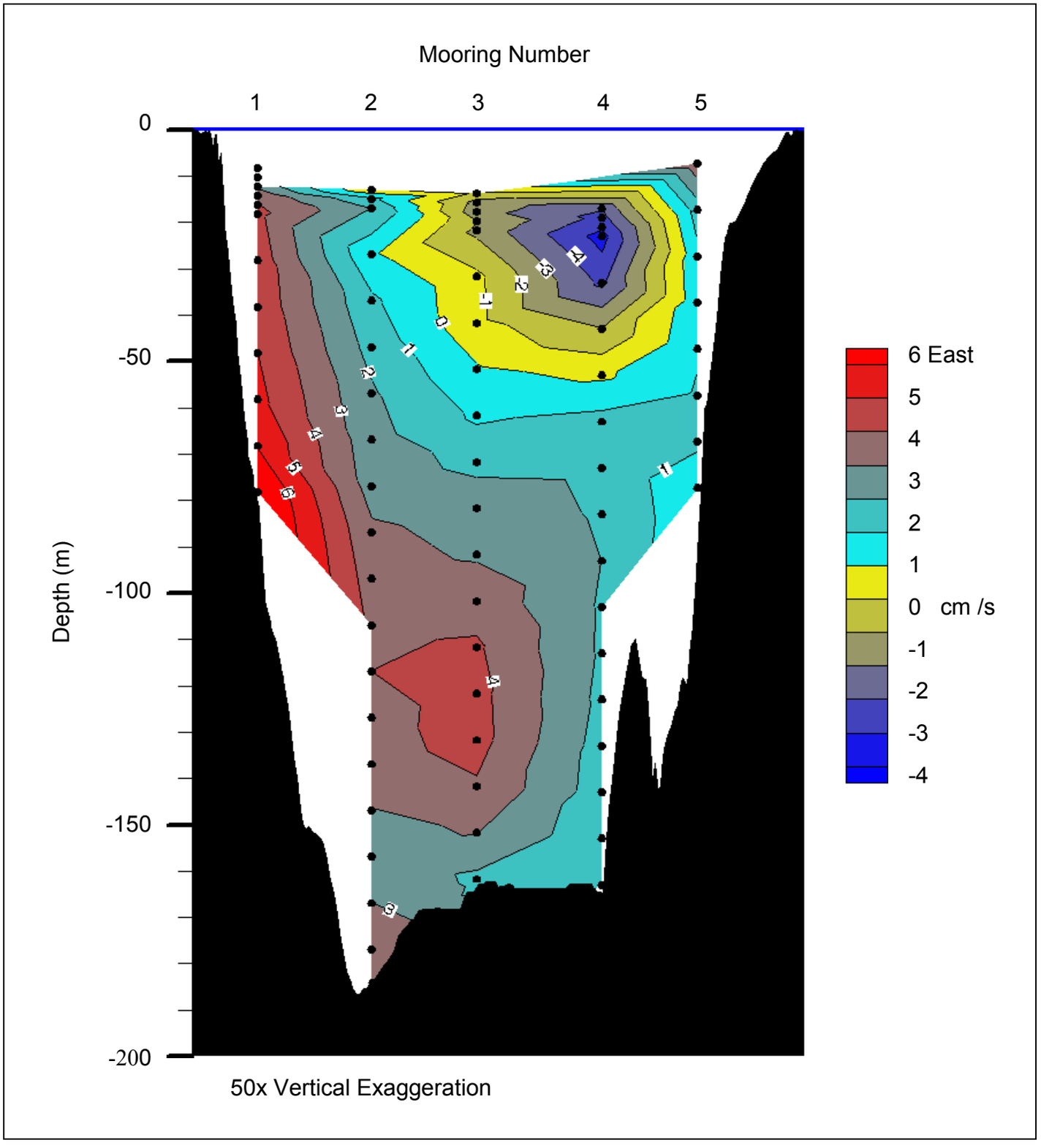
Mean currents across channel at the Point Wells section during Deployment 4 (D4a; January 27-February 23, 2001). Contour interval is 1 cm/s. Dots denote depths of 28-day means at ADCP moorings 19-24 and the Aanderaa mooring (A). See Figure 2 for locations.

Figure 29. **Mean currents across the Point Wells section:**



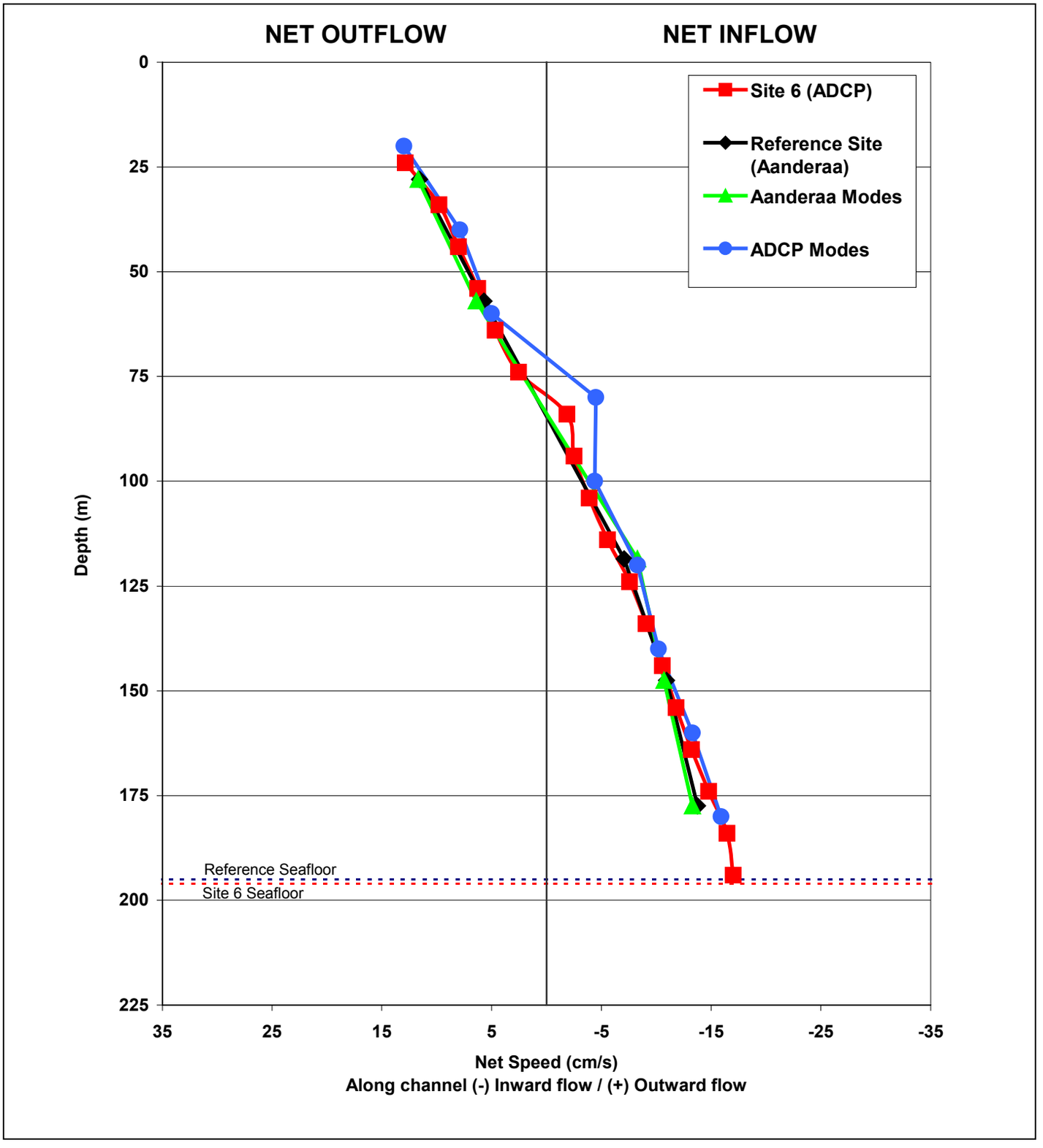
Mean currents across channel at the Point Wells section during Deployment (D4b; February 20-March 20, 2001). Contour interval is 1 cm/s. Dots denote depths of 28-day means at ADCP moorings 19-24 and the Aanderaa mooring (A). See Figure 2 for locations.

Figure 30. **Mean currents across the Edwards Point section:**



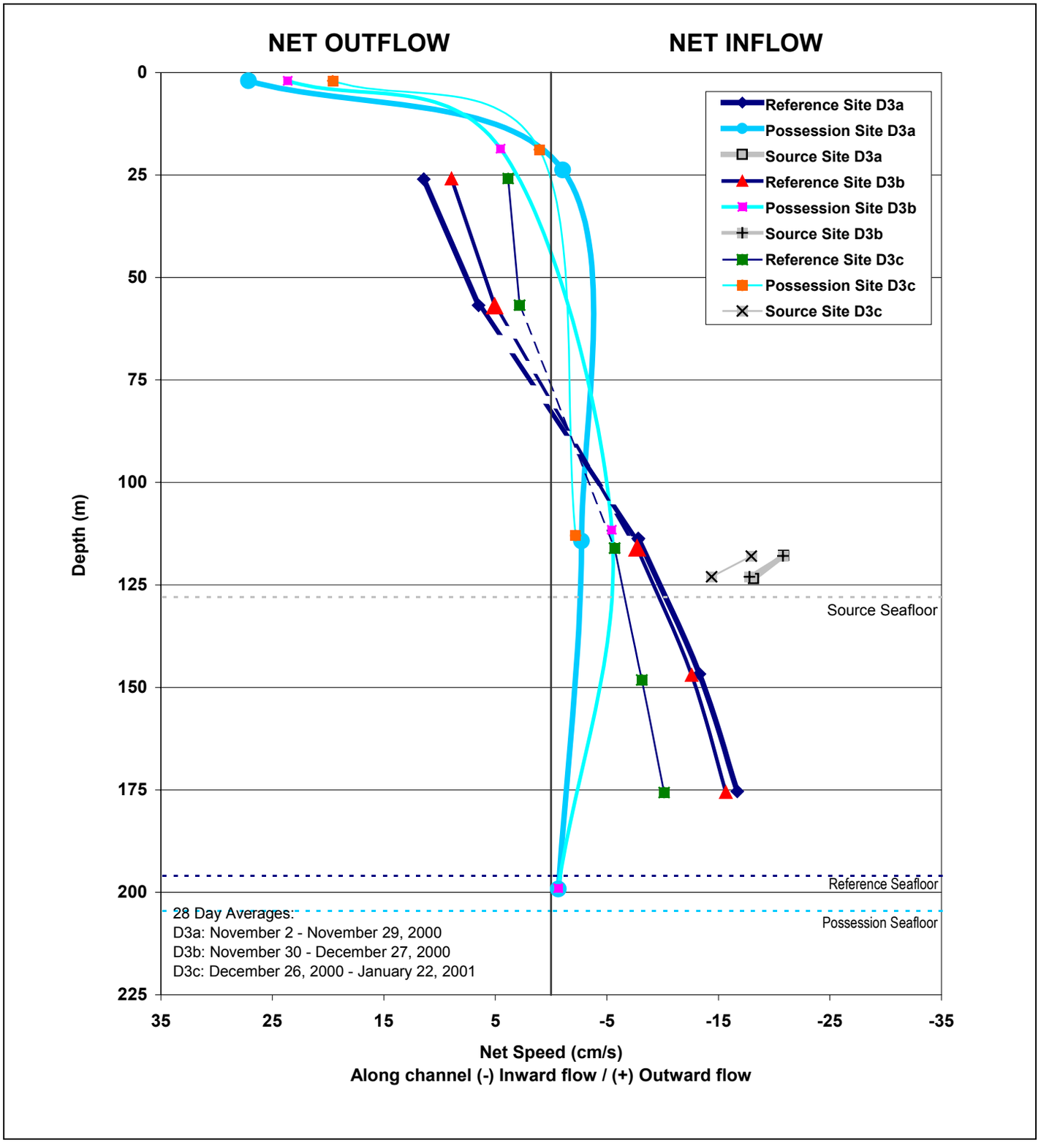
Mean currents across channel at the Edwards Point section during Deployment 1 (D1; July 14-August 10, 2000). Contour interval is 1 cm/s. Dots denote depths of 28-day means at ADCP moorings 1-5. See Figure 2 for locations.

Figure 31. **Aanderaa, ADCP and mode current comparison**



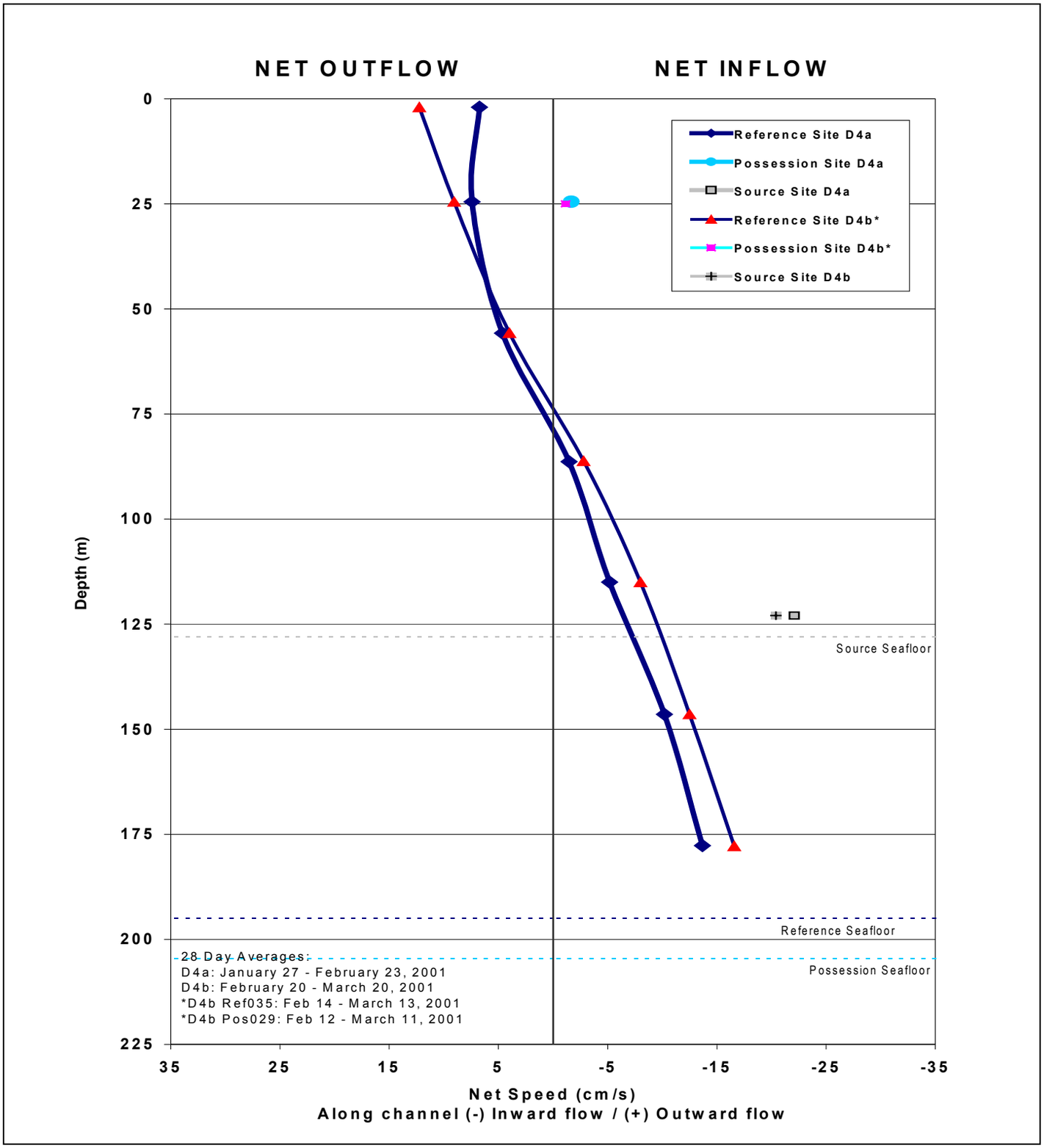
Net speeds from Aanderaa current meters at the Main Basin Reference Site compared with those from an ADCP meter at Mooring 6 during July 14 – August 11, 2000, and Mode 1 currents from both instruments. The ADCP and Aanderaa moorings were in close proximity (Figure 2). Aanderaa data were at fixed depths; ADCP net currents, at 20-m intervals above bottom; and ADCP mode currents, at 20-m intervals below the surface.

Figure 32. **Mean current profiles: November 2000- January**



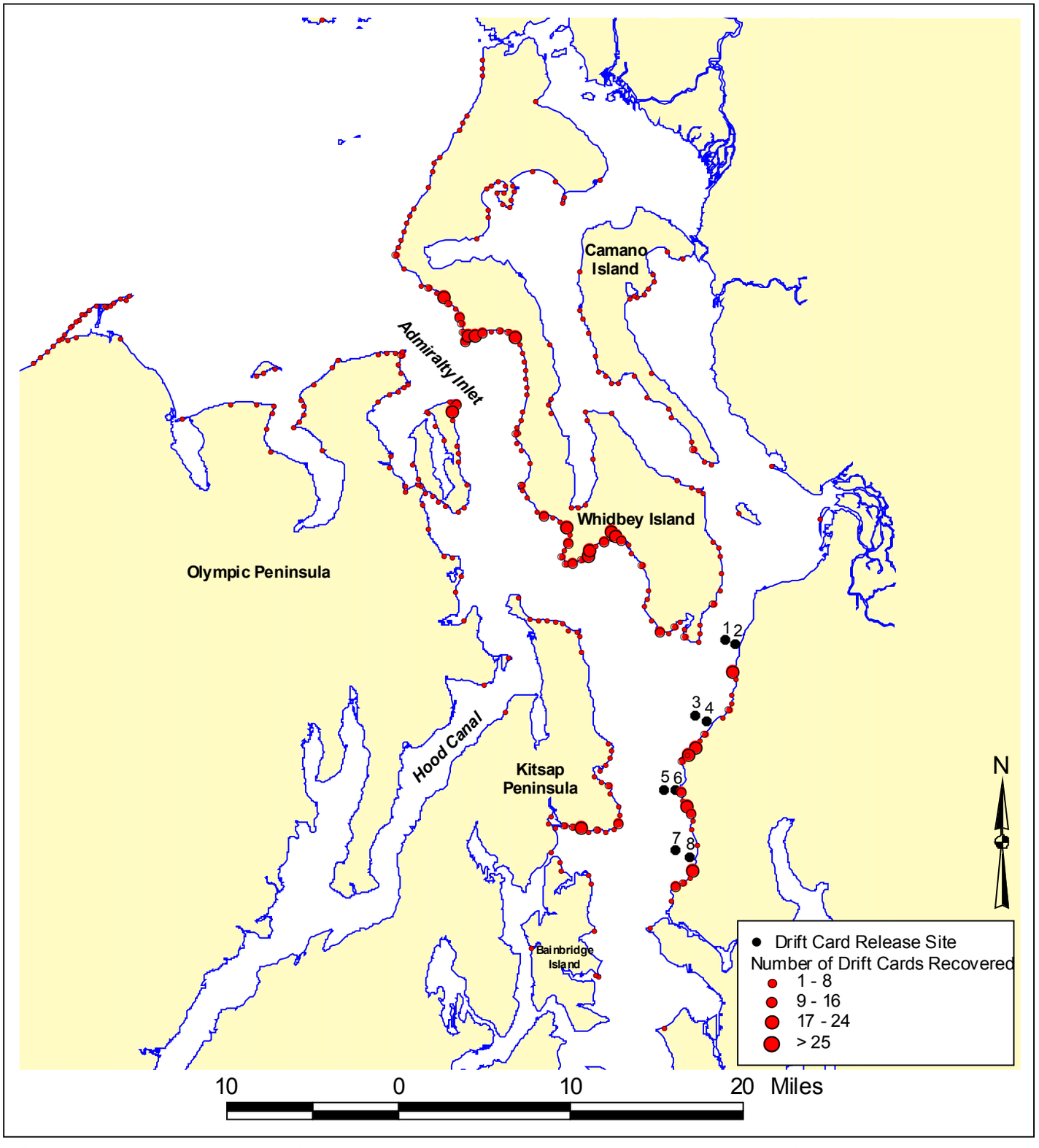
Along-channel average flow at the Main Basin (Reference), Possession Sound, and Admiralty Inlet (Source) Aanderaa moorings for 28-day intervals during November 2000-January 2001. Outflow from Possession Sound is southward; outflow from the Main Basin and Admiralty Inlet is northward. The Possession Sound mean currents were used in Figures 25-27.

Figure 33. **Mean current profiles: January-March 2001**



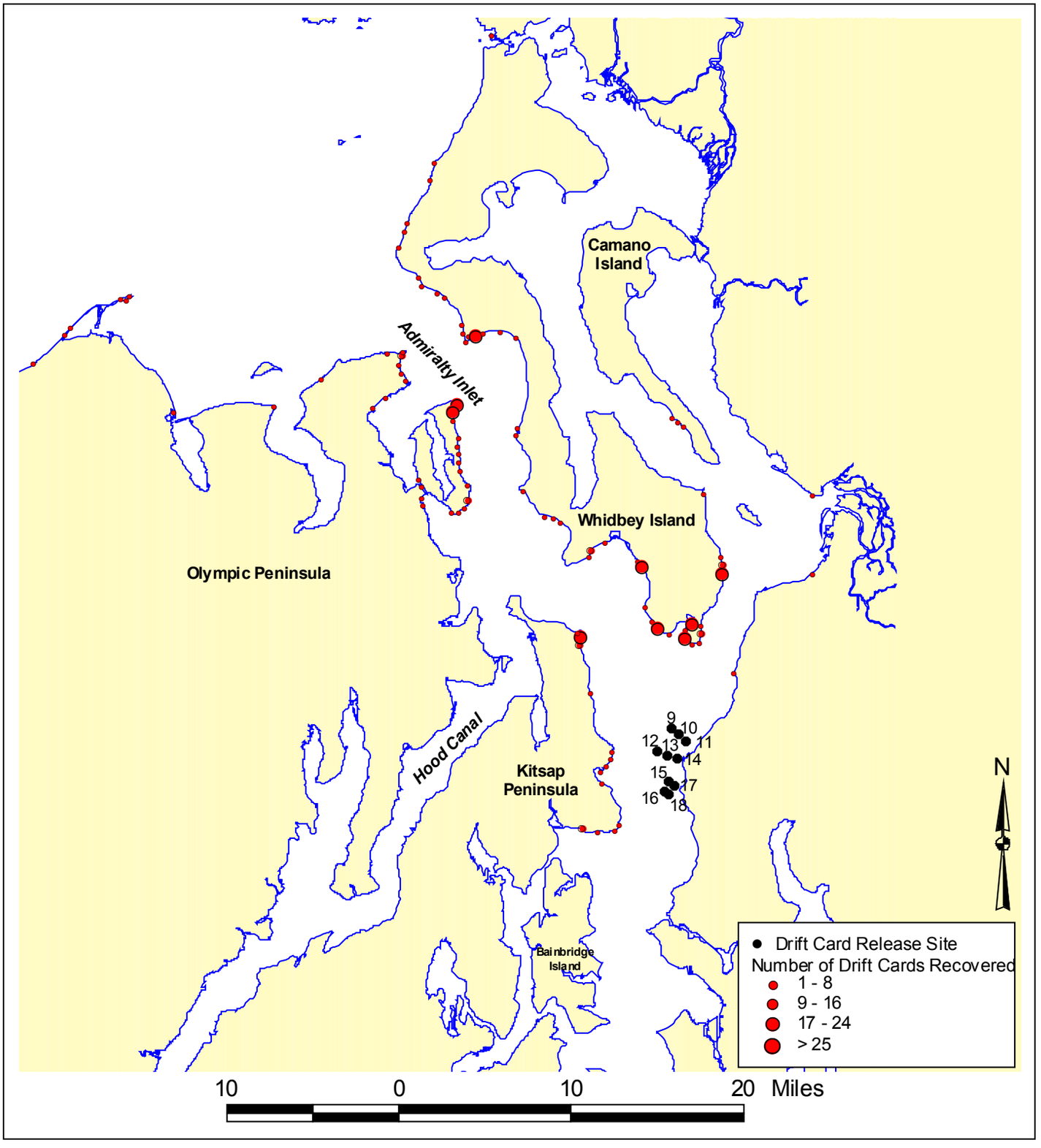
Along-channel average flow at the Main Basin (Reference), Possession Sound, and Admiralty Inlet (Source) Aanderaa moorings for 28-day intervals during January-March 2001. Outflow from Possession Sound is southward; outflow from the Main Basin and Admiralty Inlet is northward. The Main Basin mean currents were used in Figures 15-16.

Figure 34. **Drift card recovery locations: releases 1-9**



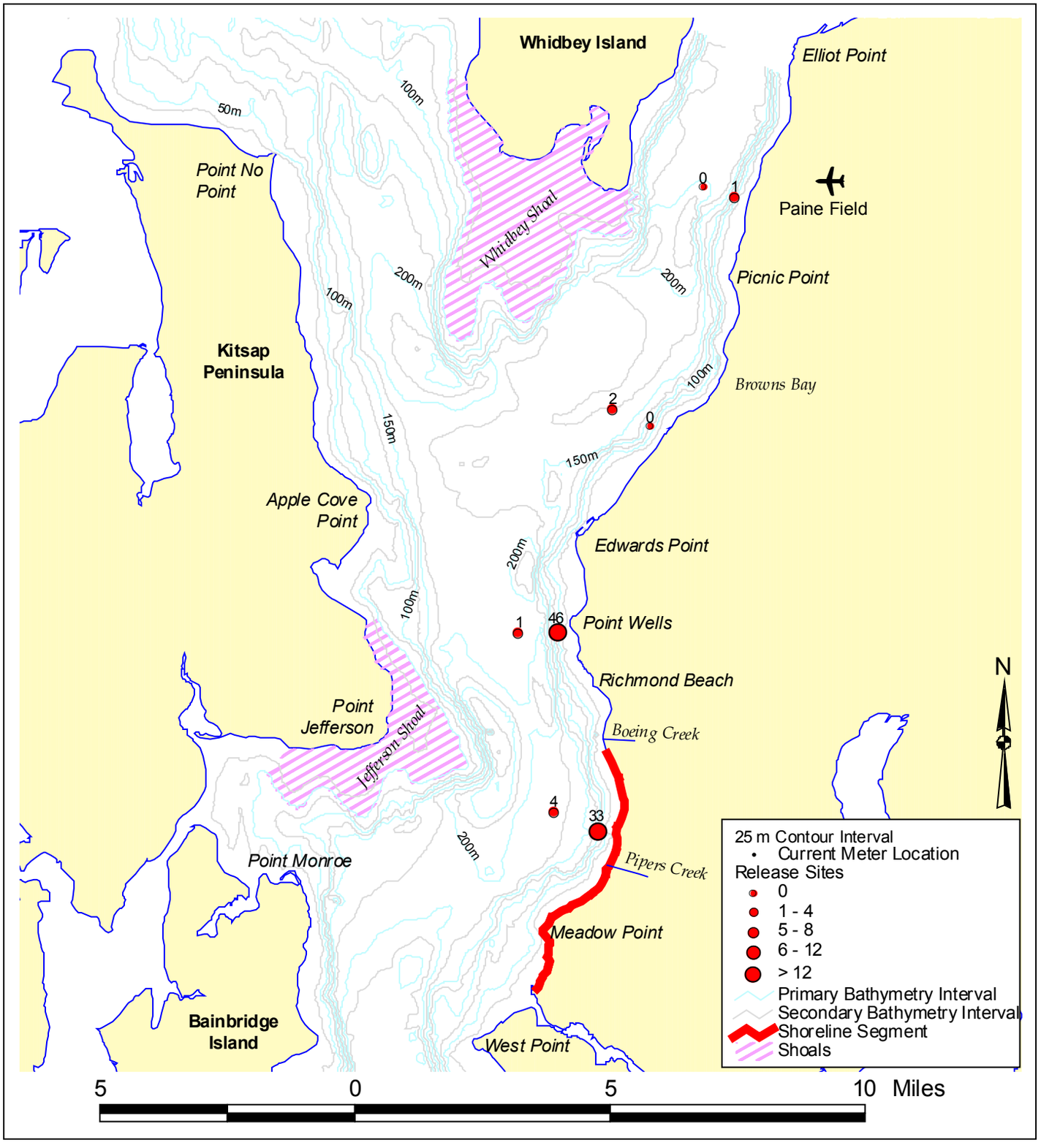
Releases 1-9 were at sites 1–8, and recovery locations were reported by beachcombers.

Figure 35. **Drift card recovery locations: releases 10-14**



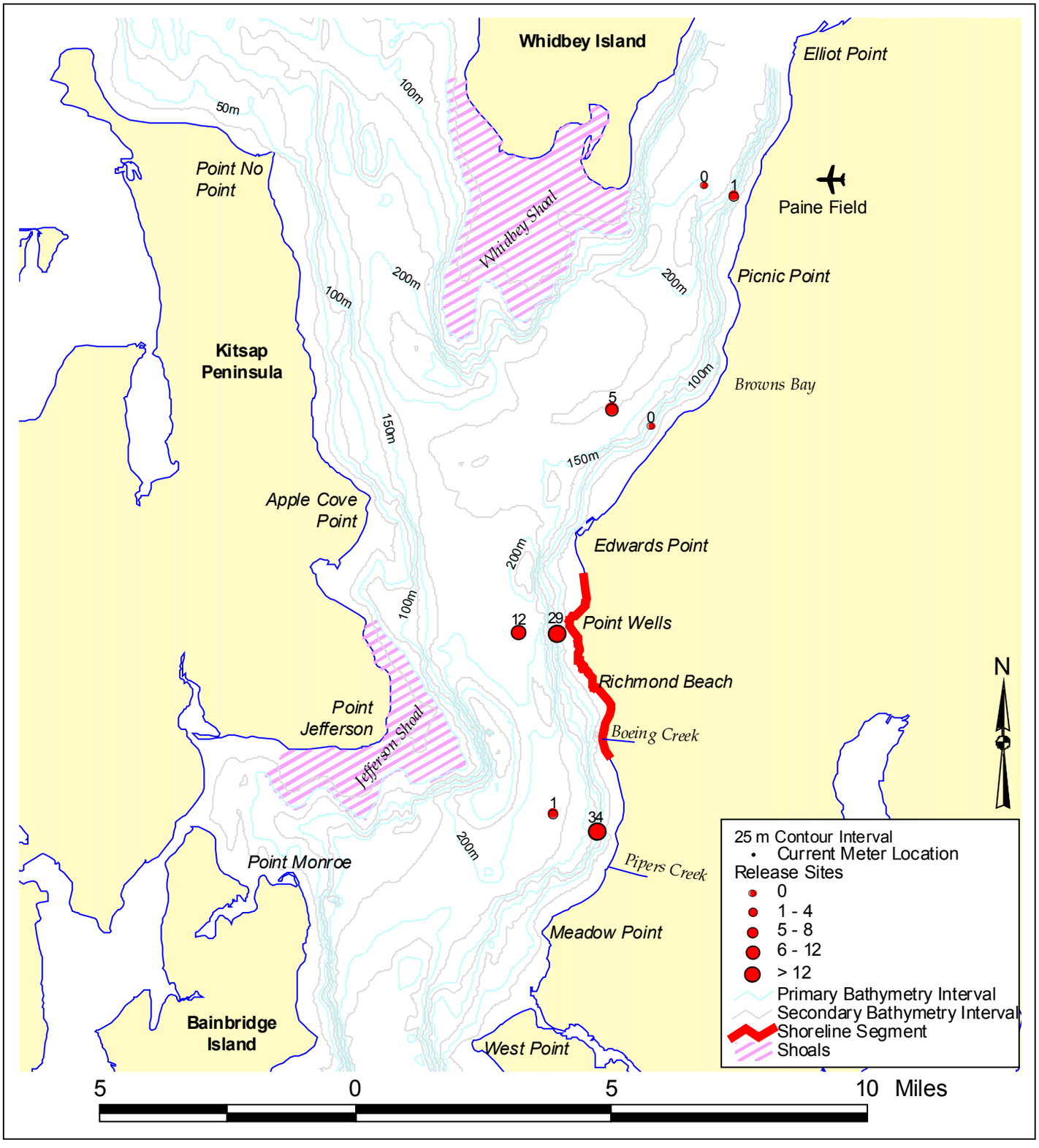
Releases 10-14 were at sites 9-18, and recovery locations were reported by beachcombers.

Figure 36. **Origins of drift cards near Meadow Point: releases 1-**



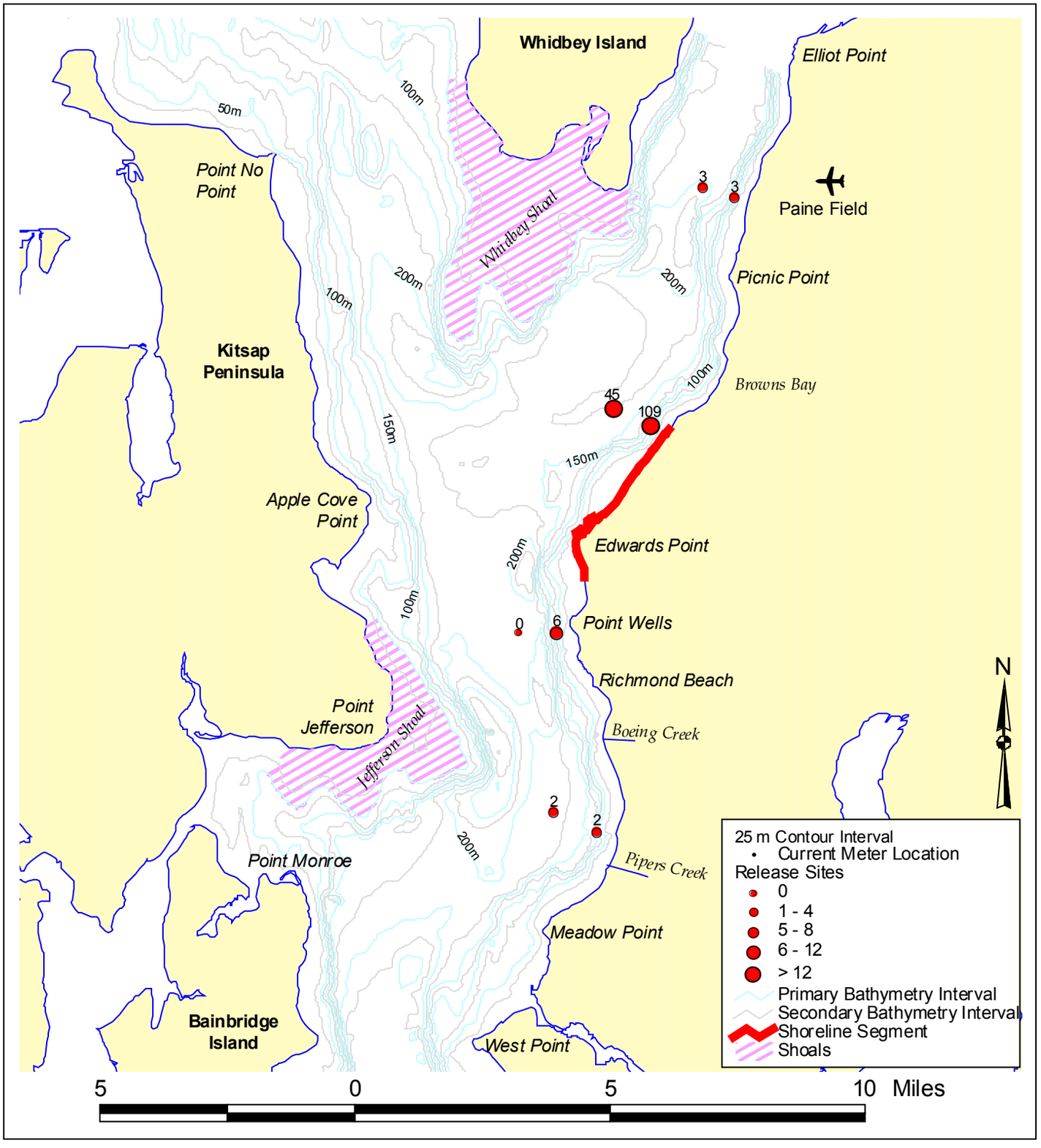
Origins of drift cards found near Meadow Point (bold red) from releases 1-9. For example, 46 cards were found from Release Site 6 off Point Wells.

Figure 37. **Origins of drift cards near Point Wells: releases 1-**



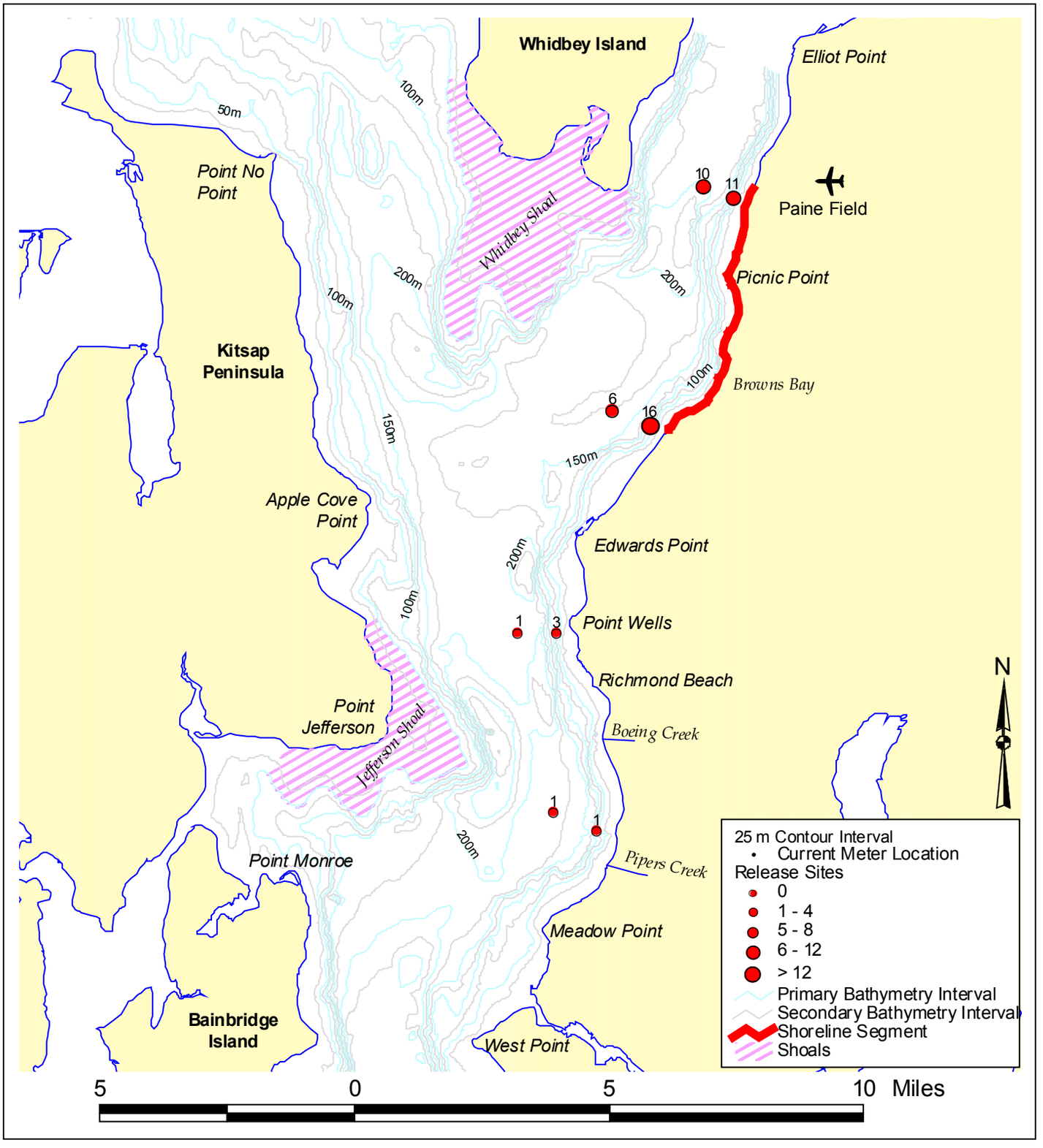
Origins of drift cards found near Point Wells (bold red) during releases 1-9. For example, 29 cards were found from just offshore at Release Site 6.

Figure 38. **Origins of drift cards near Edwards Point: releases**



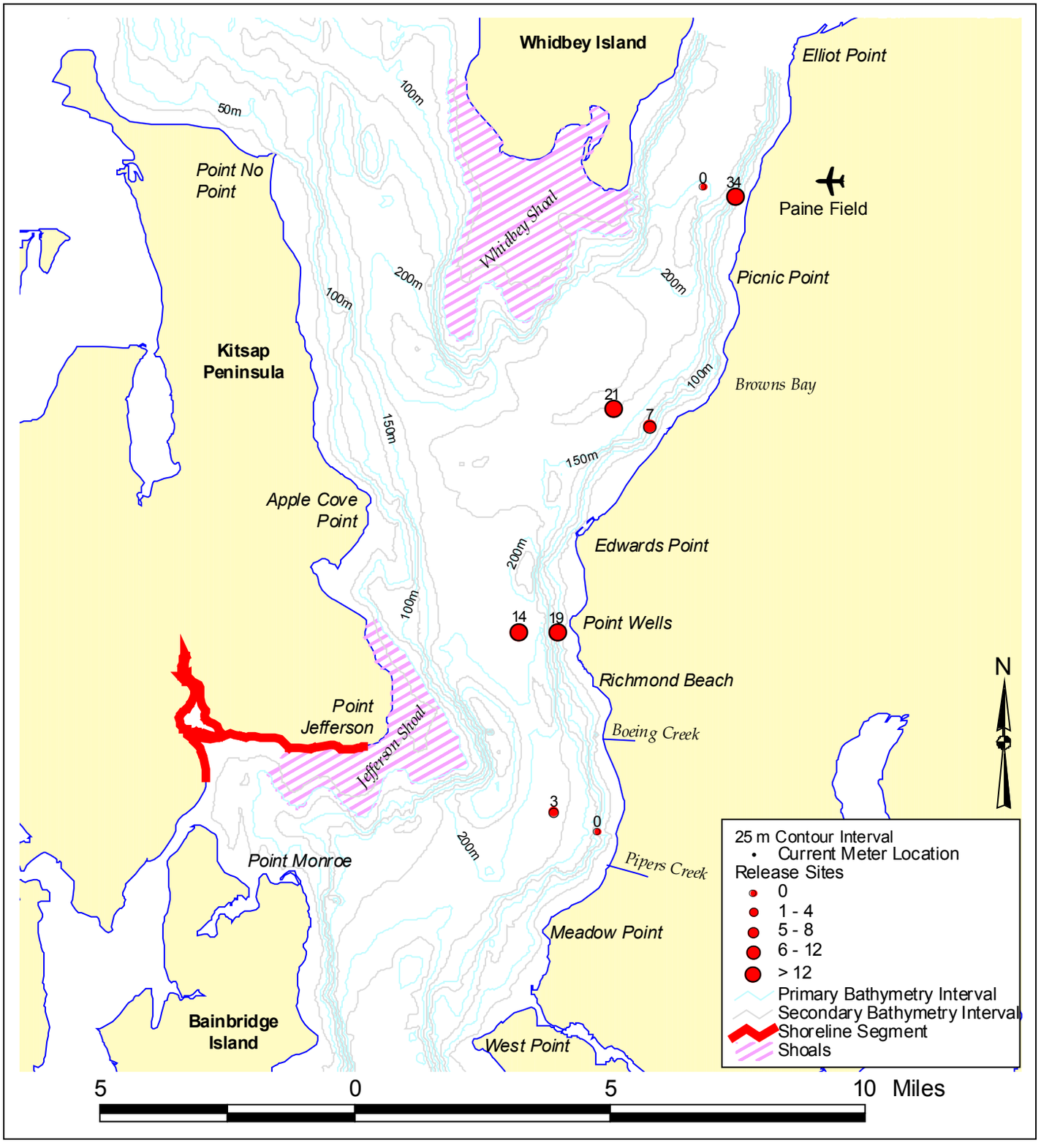
Origins of drift cards found near Edwards Point (bold red) during releases 1-9. For example, 109 cards were found from just offshore at Release Site 4.

Figure 39. **Origins of drift cards near Picnic Point: releases**



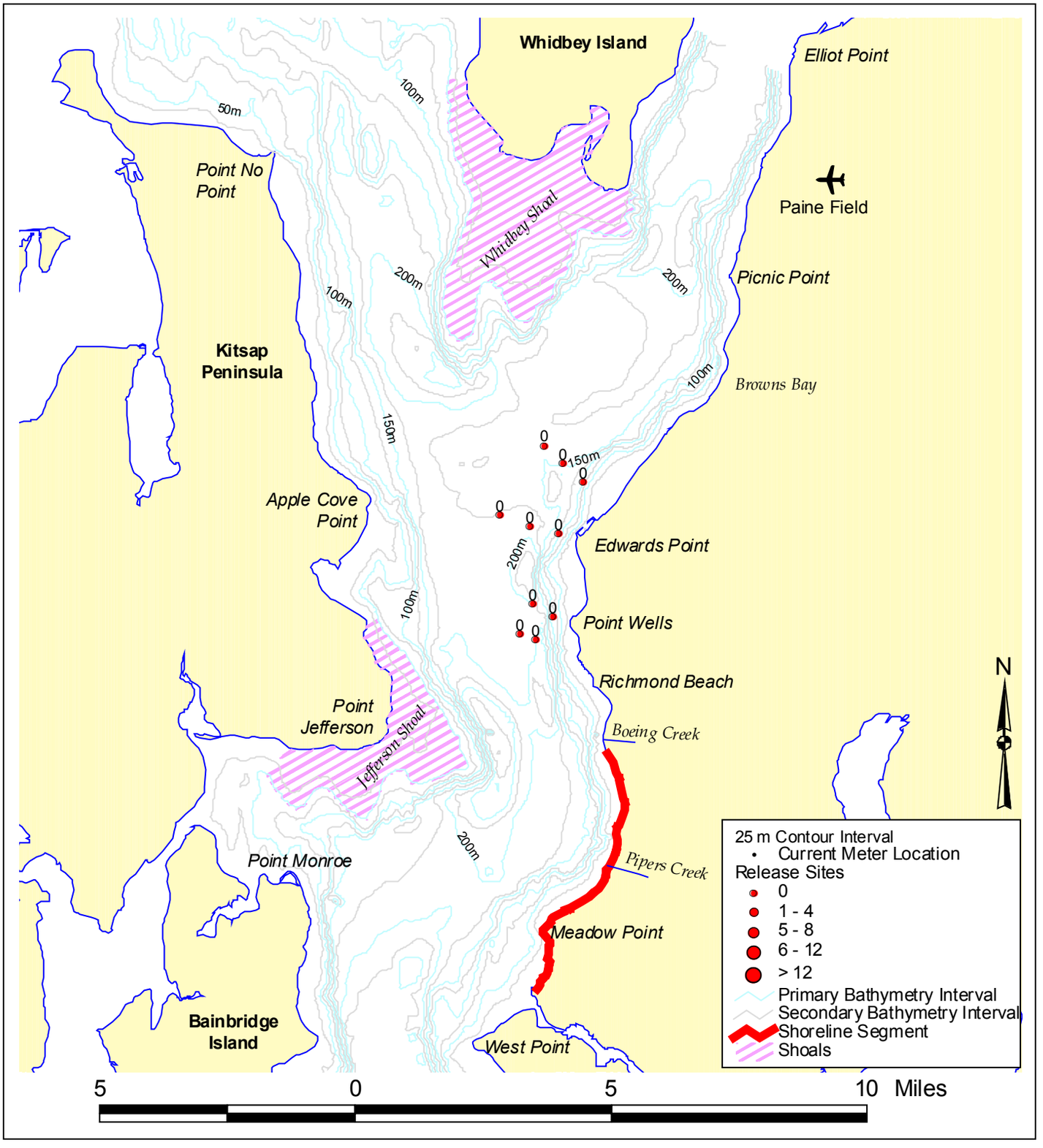
Origins of drift cards found near Picnic Point (bold red) during releases 1-9. For example, 16 cards were found from just offshore at Release Site 4 at the southern end of this shoreline segment.

Figure 40. **Origins of drift cards near Point Jefferson: releases**



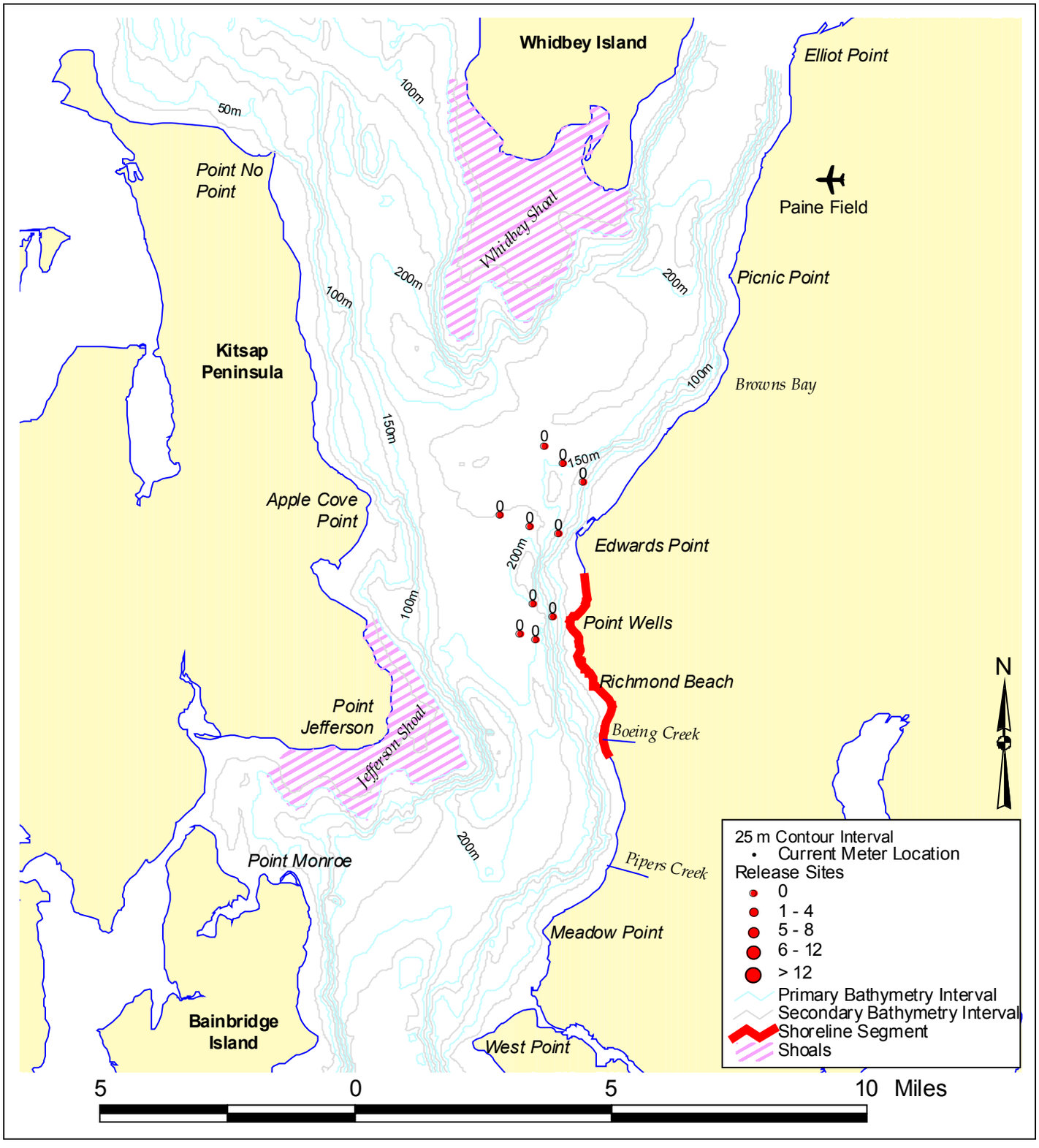
Origins of drift cards found near the Point Jefferson (bold red) during releases 1-9. For example, 34 cards were found from Release Site 2 near Paine Field.

Figure 41. **Origins of drift cards near Meadow Point: releases 10-**



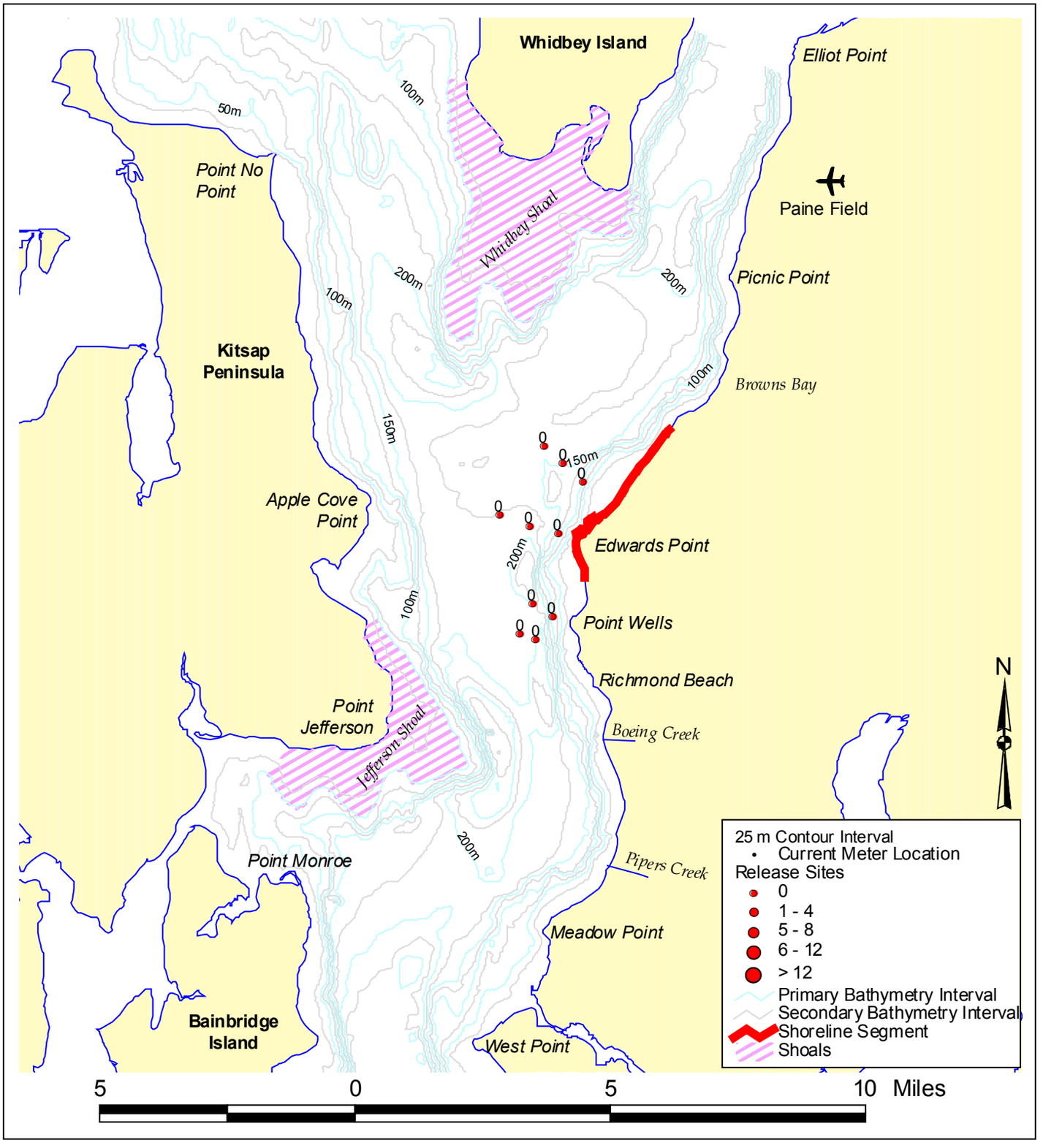
Origins of drift cards found near Meadow Point (bold red) from releases 10-14. No cards were found from any release site.

Figure 42. **Origins of drift cards near Point Wells: releases 10-**



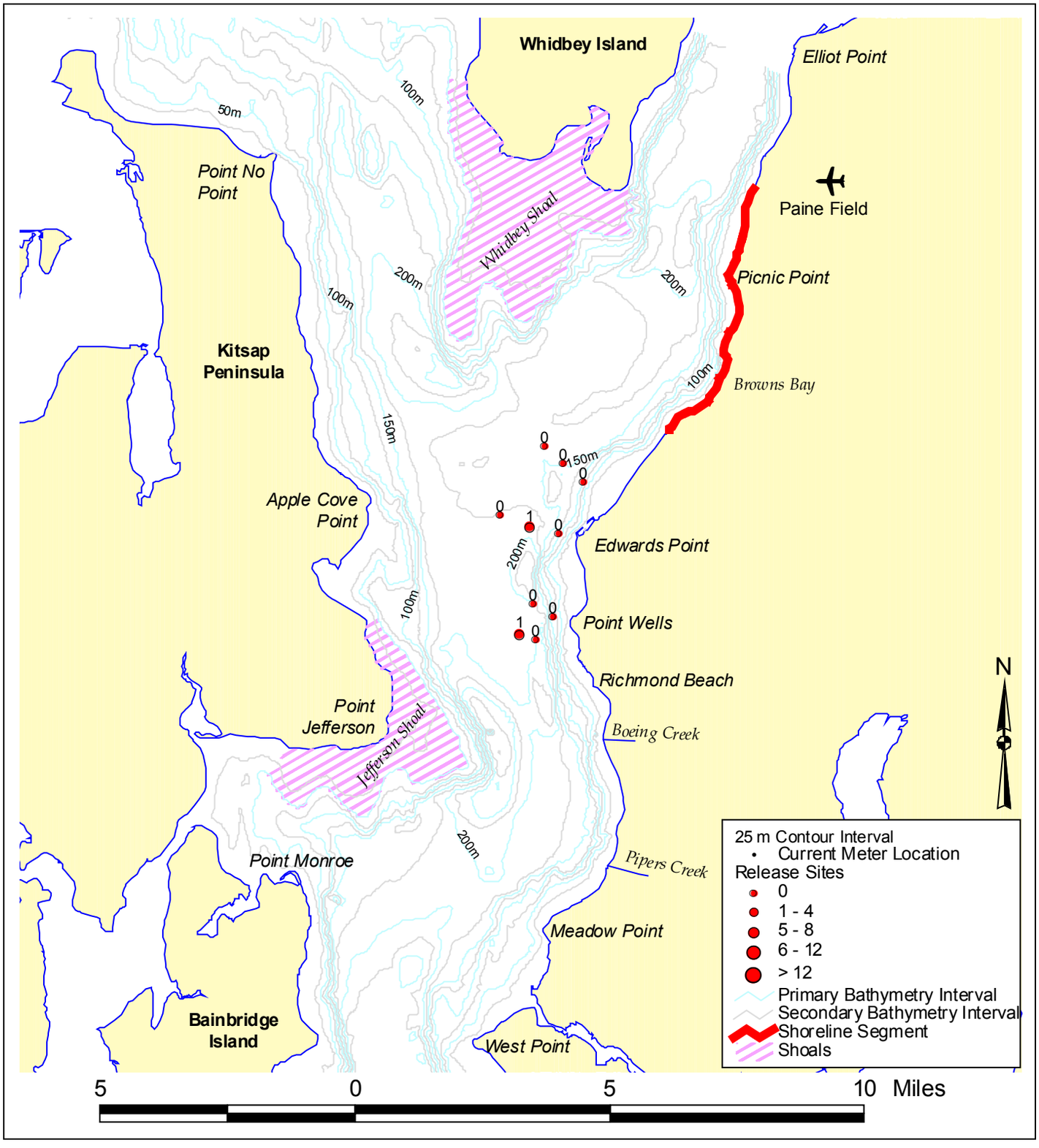
Origins of drift cards found near Point Wells (bold red) during releases 10-14. No cards found from any release site.

Figure 43. **Origins of drift cards near Edwards Point: releases 10-**



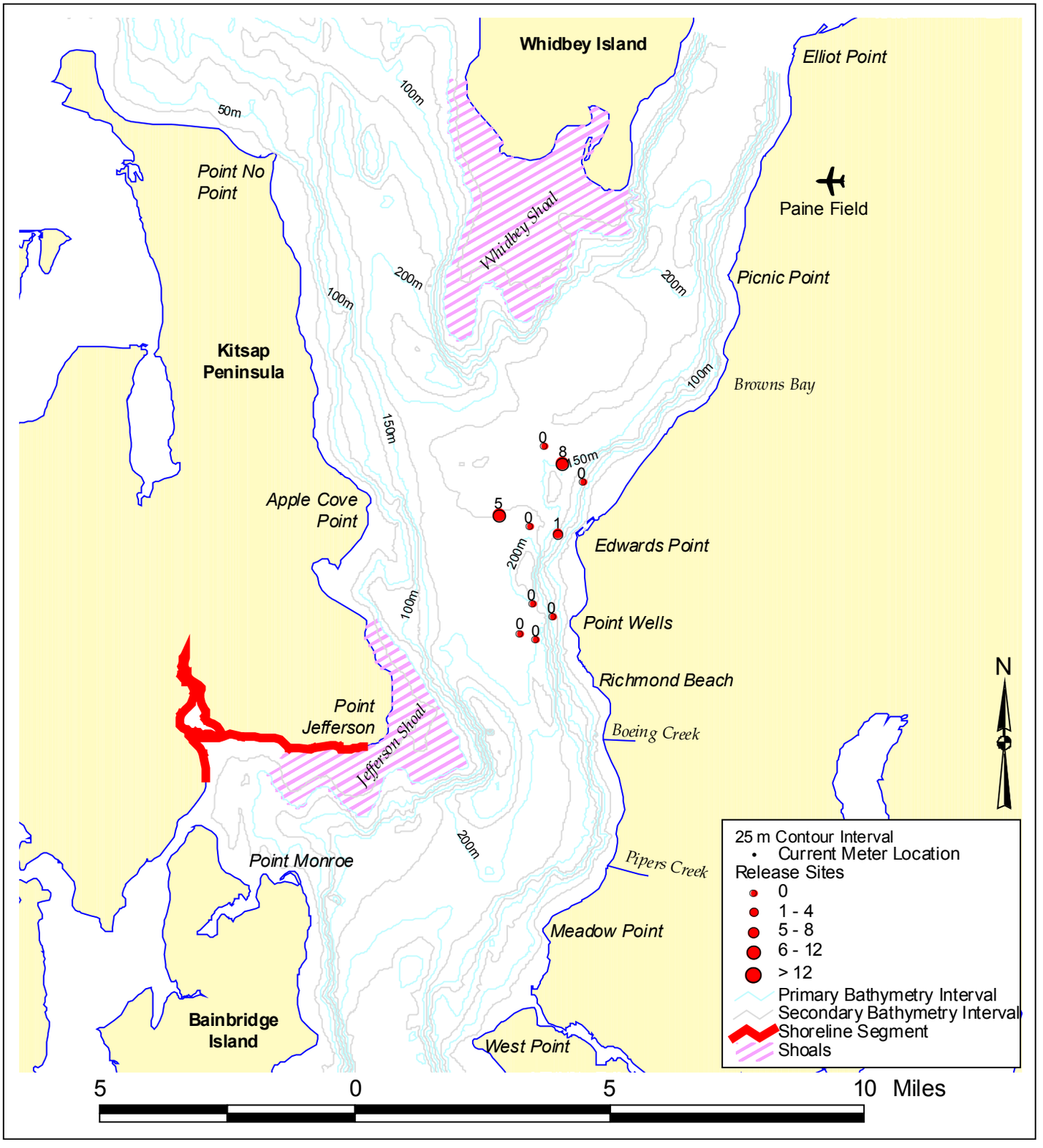
Origins of drift cards found near Edwards Point (bold red) during releases 10-14. No cards found from any release site.

Figure 44. **Origins of drift cards near Picnic Point: releases**



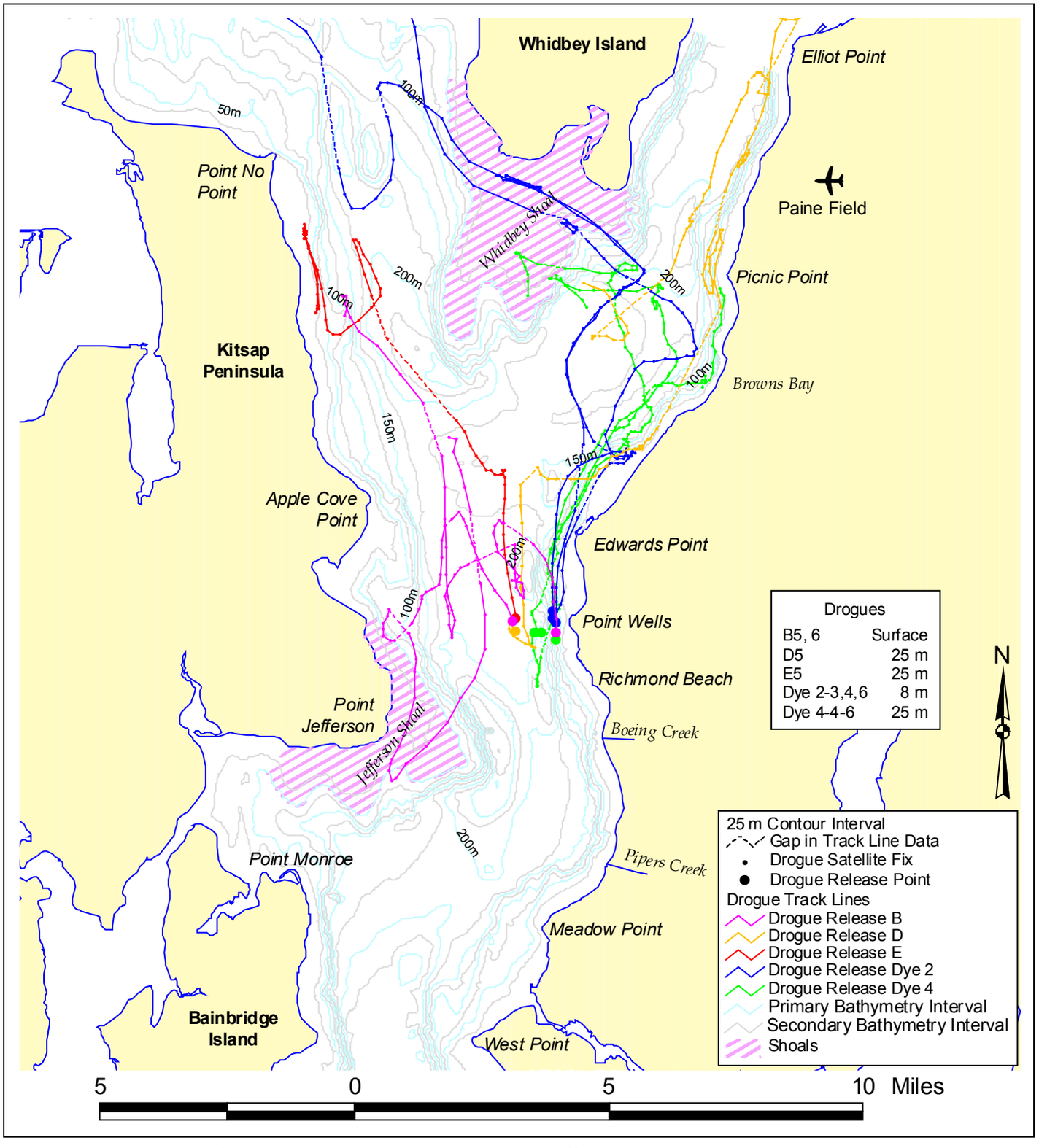
Origins of drift cards found near Picnic Point and (bold red) during releases 10-14. For example, only 1 card was found from off Edwards Point.

Figure 45. **Origins of drift cards near Point Jefferson: releases**



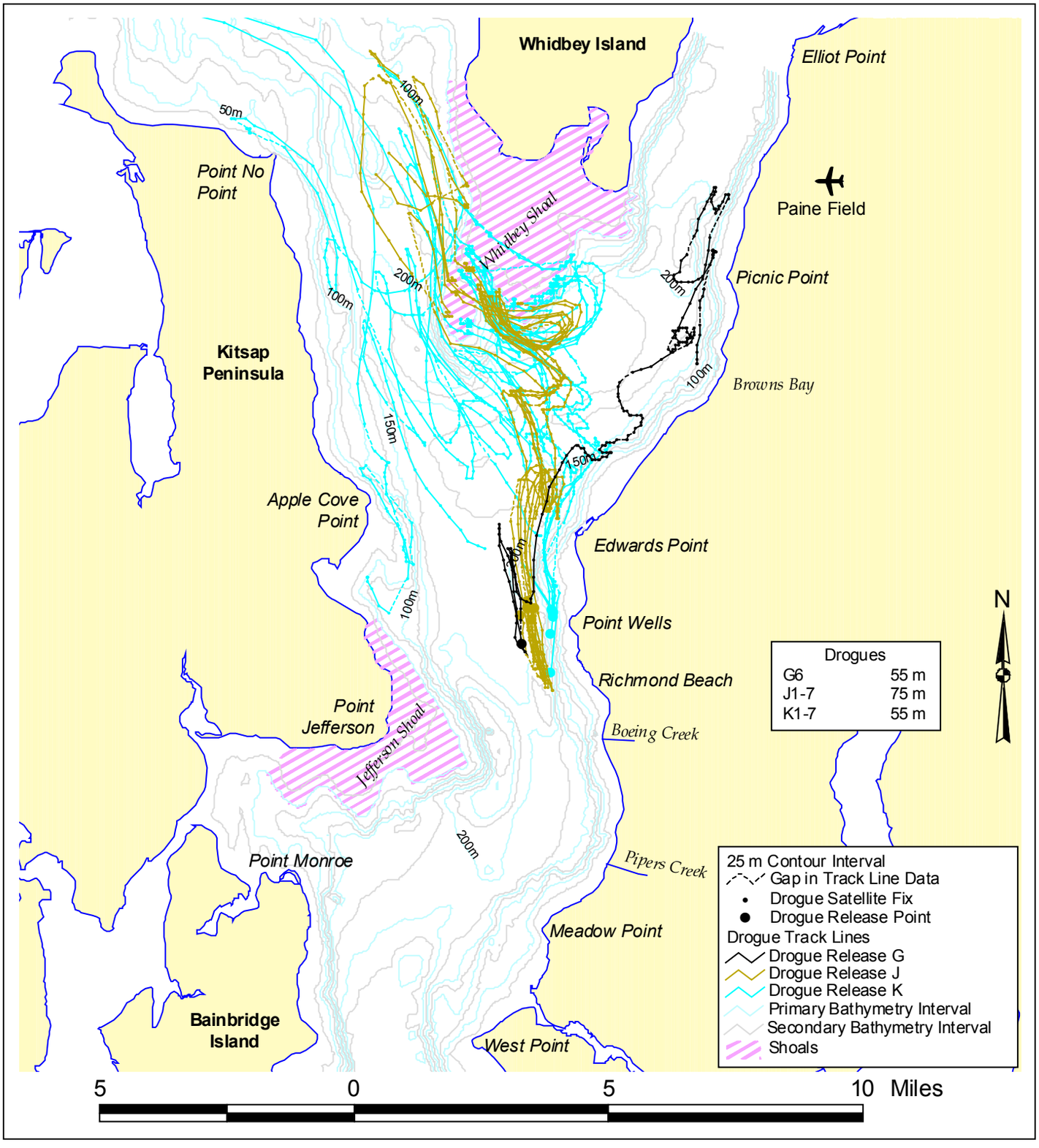
Origins of drift cards found near Point Jefferson (bold red) during releases 10-14. For example, only 6 cards were found from off Edwards Point.

Figure 46. **Composite drogue trajectories off Point Wells: 0-25**



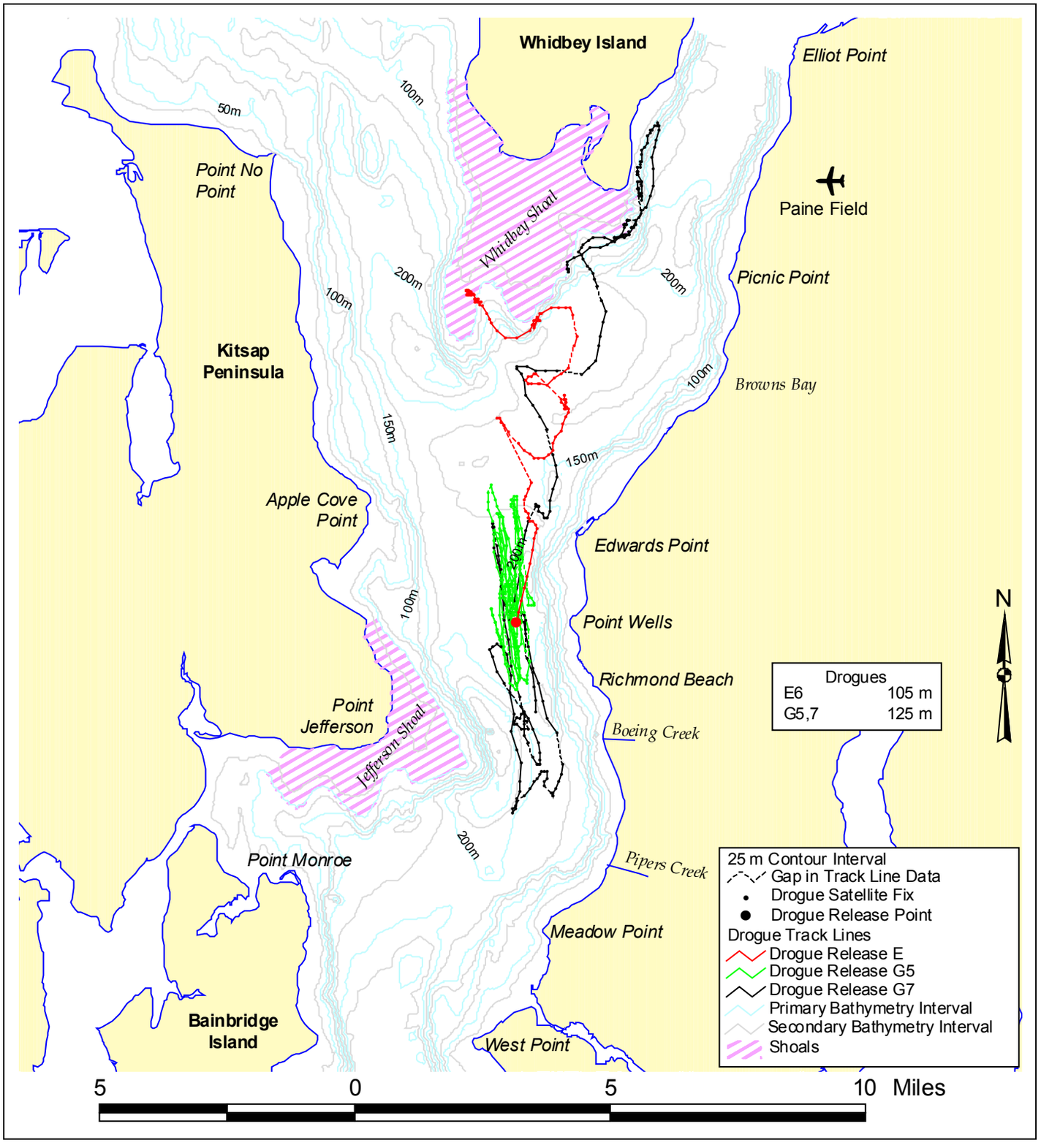
Drogue trajectories from 10 drogues, 5 deployments off Point Wells in the 0-25 m depth range.

Figure 47. **Composite drogue trajectories off Point Wells: 55-75**



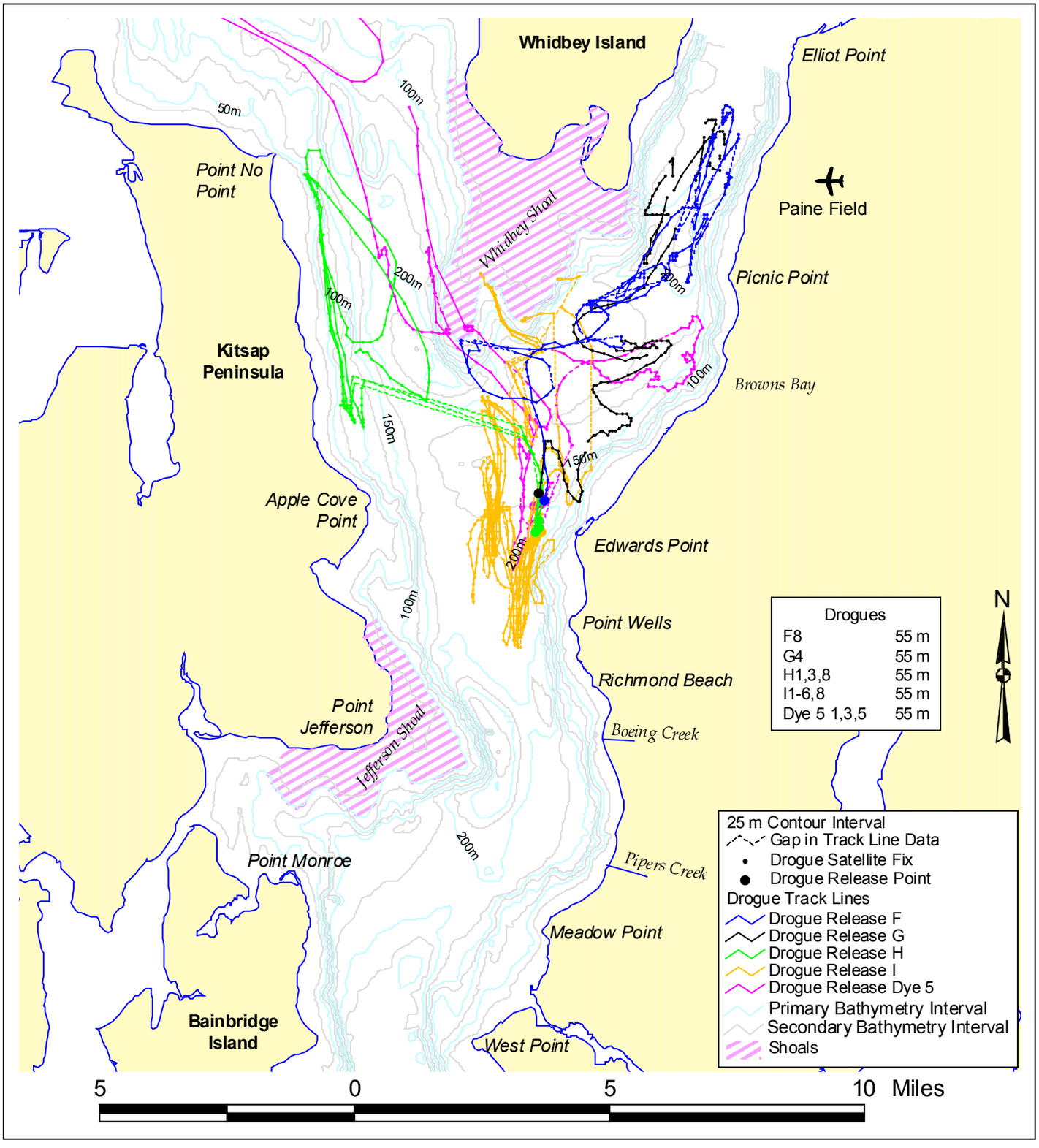
Drogue trajectories from 15 drogues, 3 deployments off Point Wells in the 55-75 m depth range.

Figure 48. **Composite drogue trajectories off Point Wells: 105-155**



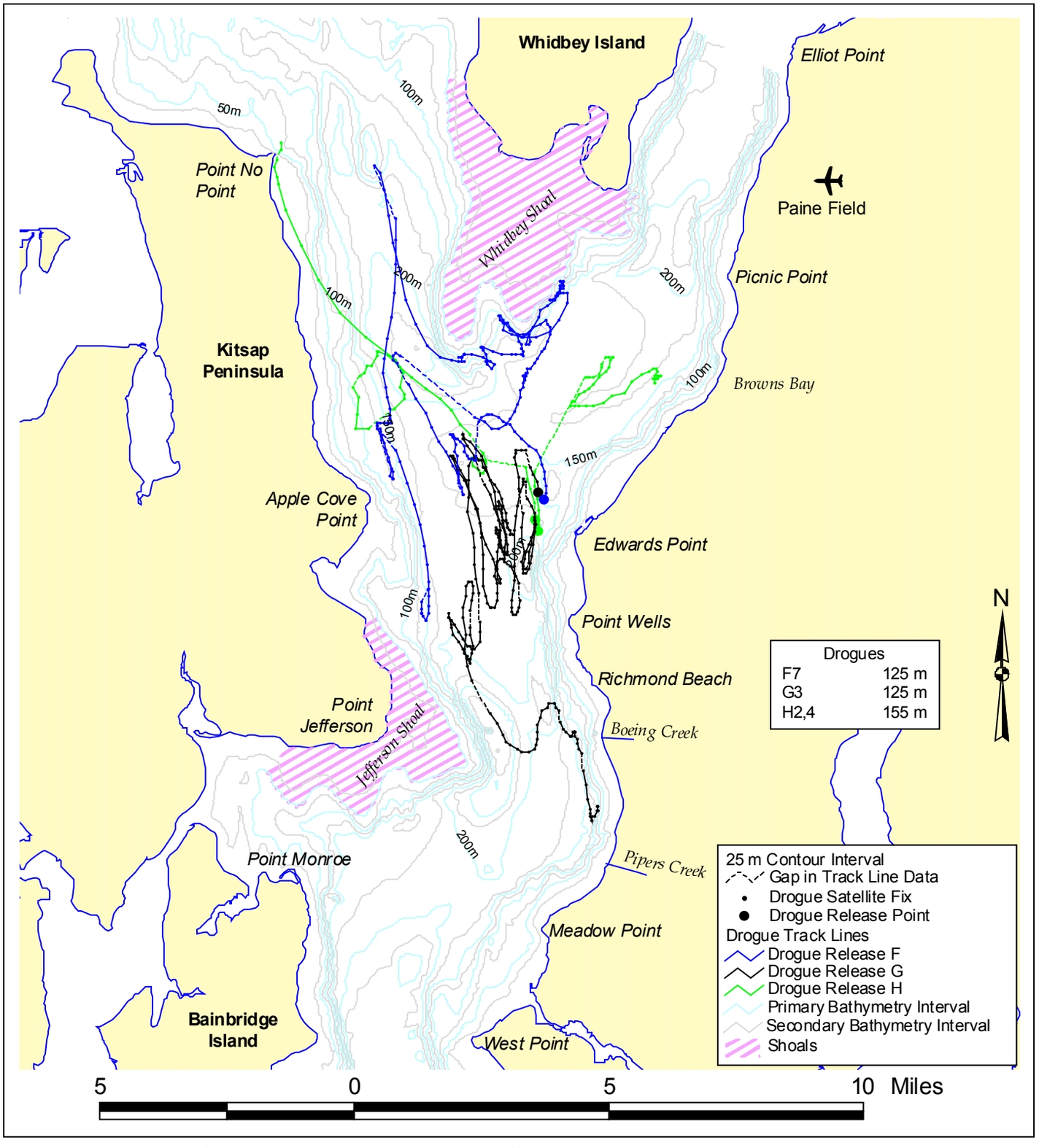
Drogue trajectories from 3 drogues, 2 deployments off Point Wells in the 105-155 m depth range.

Figure 49. **Composite drogue trajectories off Edwards Point: 55-75**



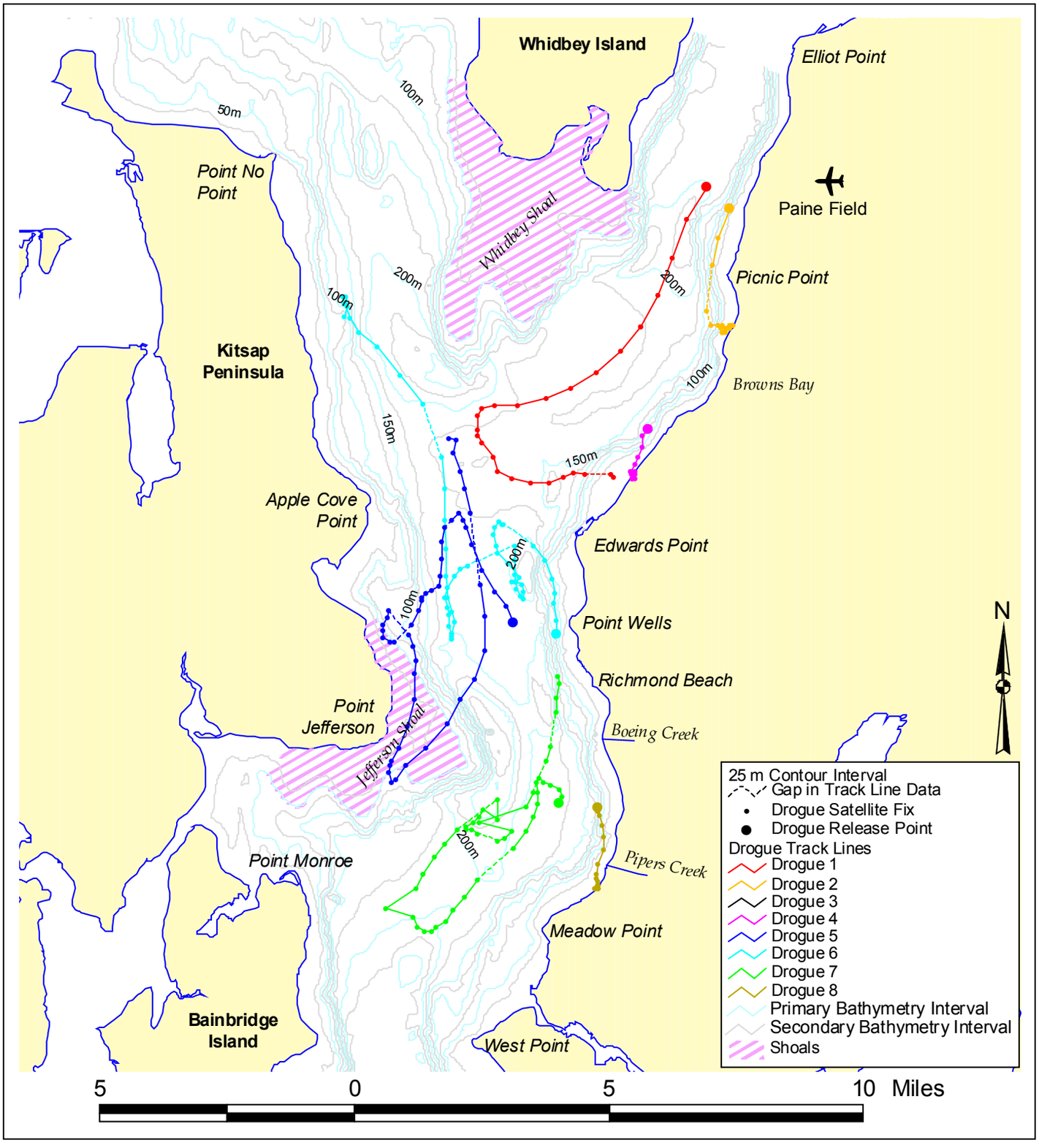
Drogue trajectories from 15 drogues, 5 deployments off Edwards Point in the 55-75 m depth range.

Figure 50. **Composite drogue trajectories off Edwards Point: 105-**



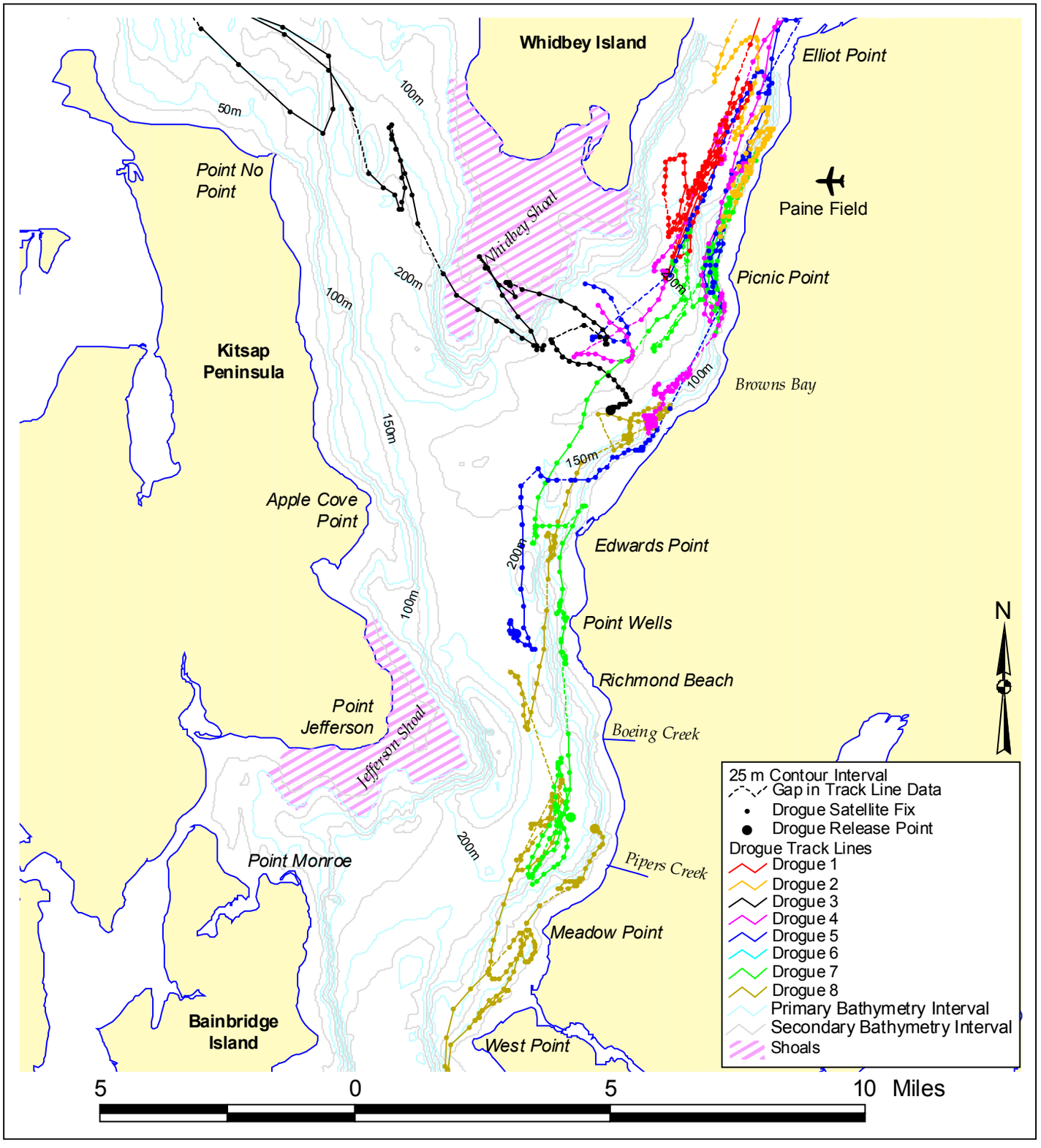
Drogue trajectories from 4 drogues, 3 deployments off Edwards Point in the 105-155 m depth range.

Figure 51. **Drogue trajectories during Deployment B**



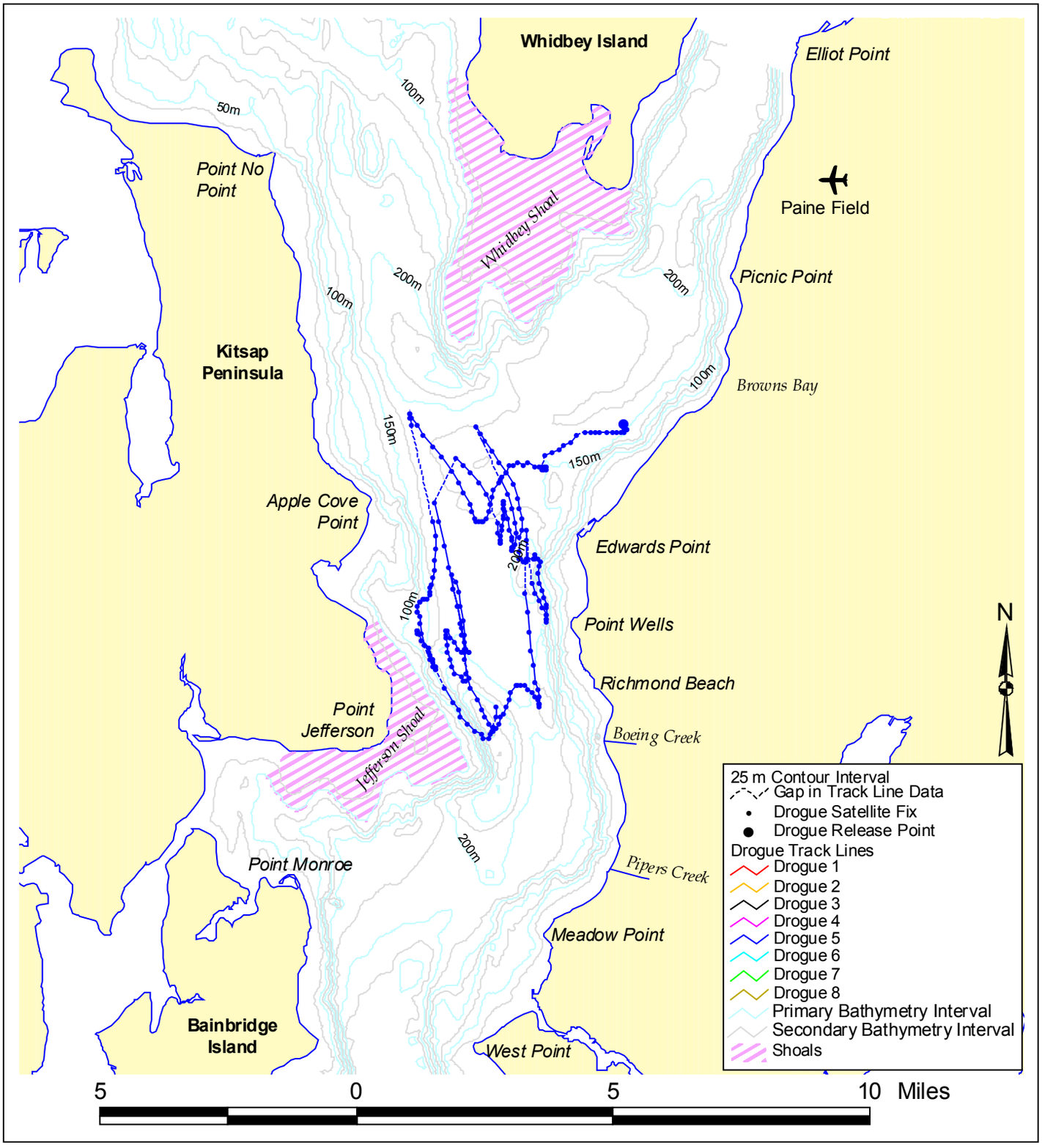
Seven drogues were deployed at the sea surface at drift card sites 1, 2, 4-8 in August 2000. The deployment was for a tidal day and simultaneous with drift card releases.

Figure 52. **Drogue trajectories during Deployment D**



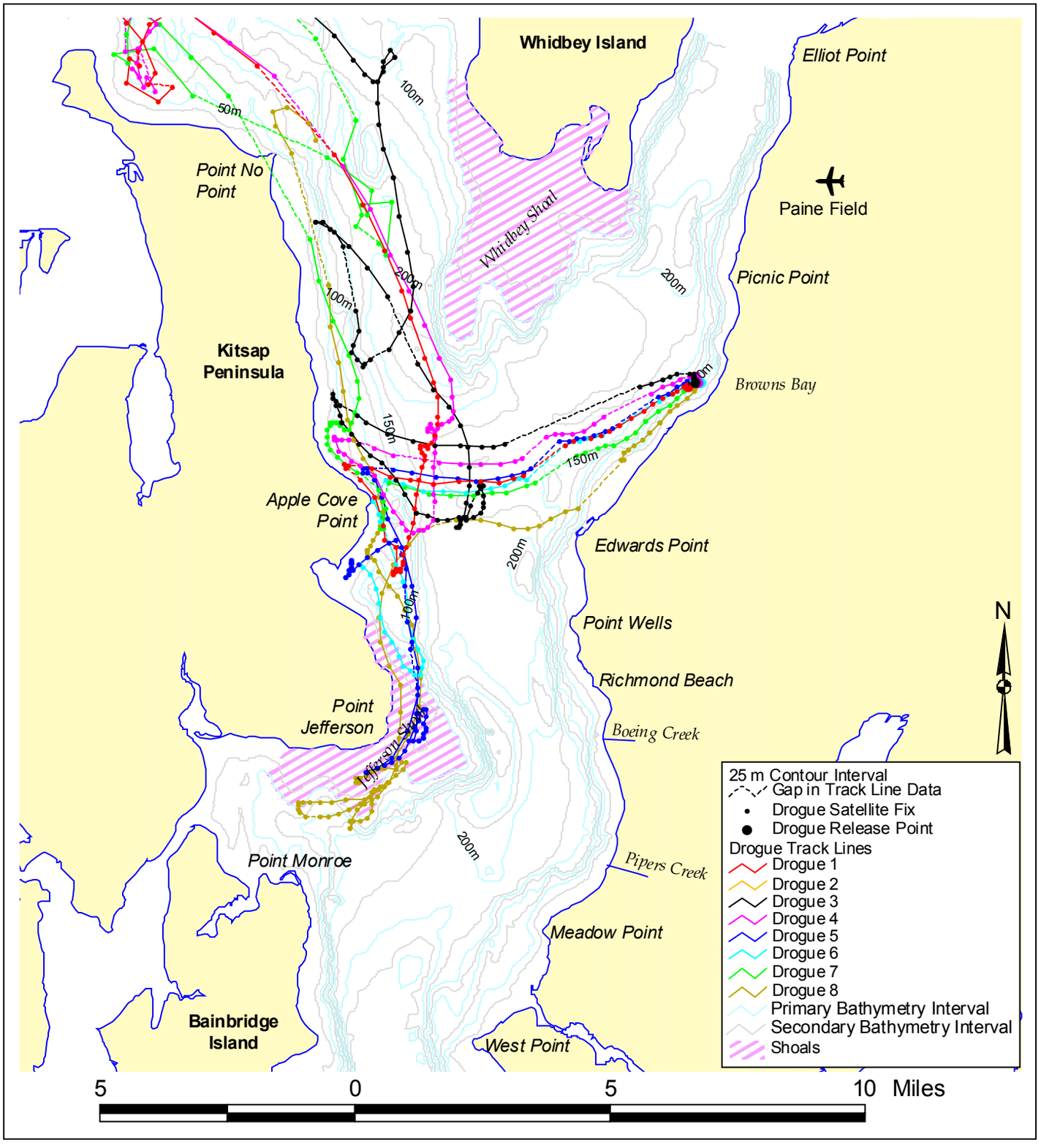
Seven drogues were deployed at 20-30 m at drift card sites 1-5, 7, 8 in October 2000. Drogue #6 at the Point Wells inshore site failed.

Figure 53. **Drogue trajectory during Deployment F**



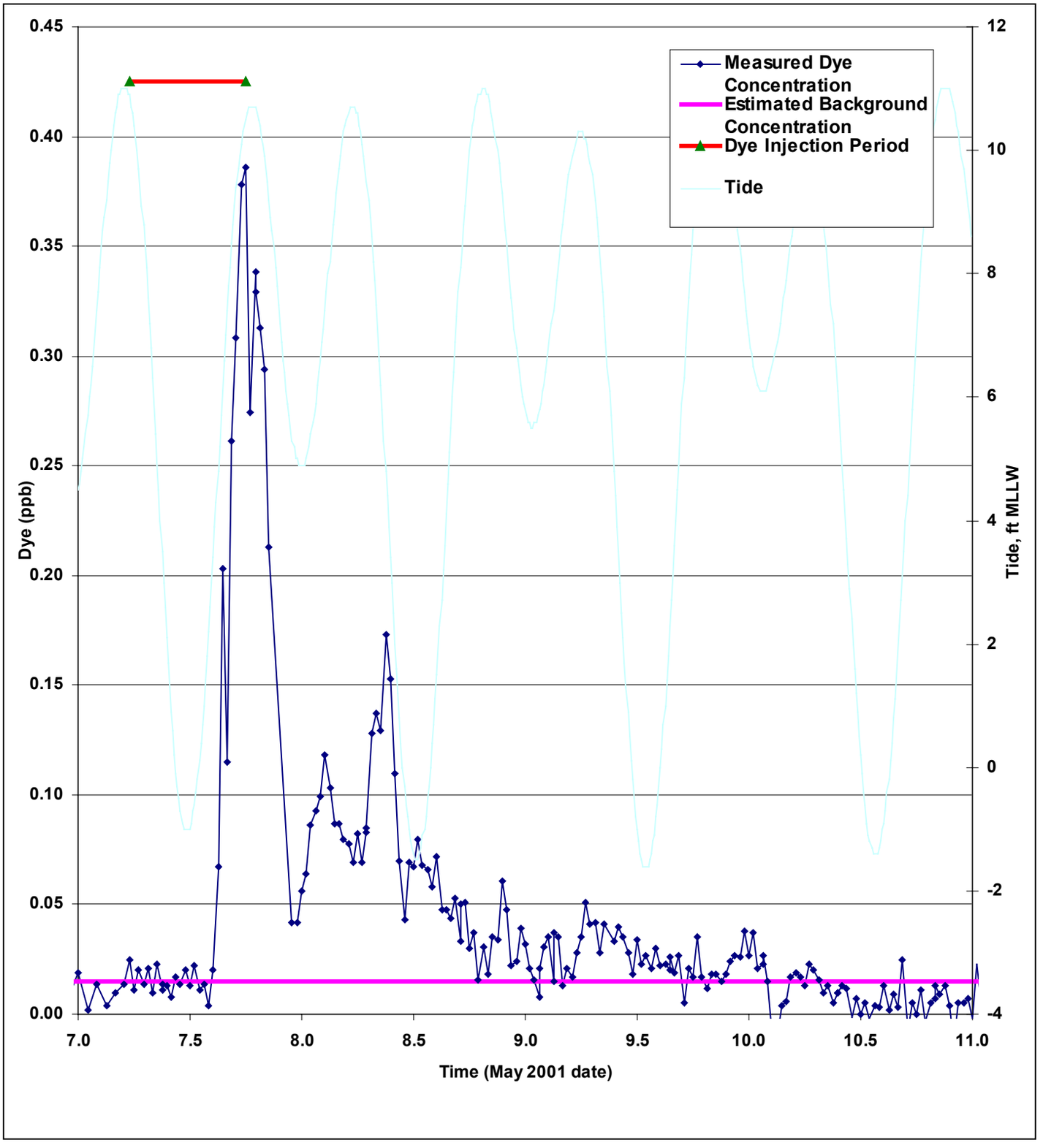
Drogue #5 was deployed at 120-130 m at offshore drift card site 3 in January 2001. This drogue traveled 1 1/2 times around the Main Basin recirculation feature.

Figure 54. **Drogue trajectories during Dye Study 1**



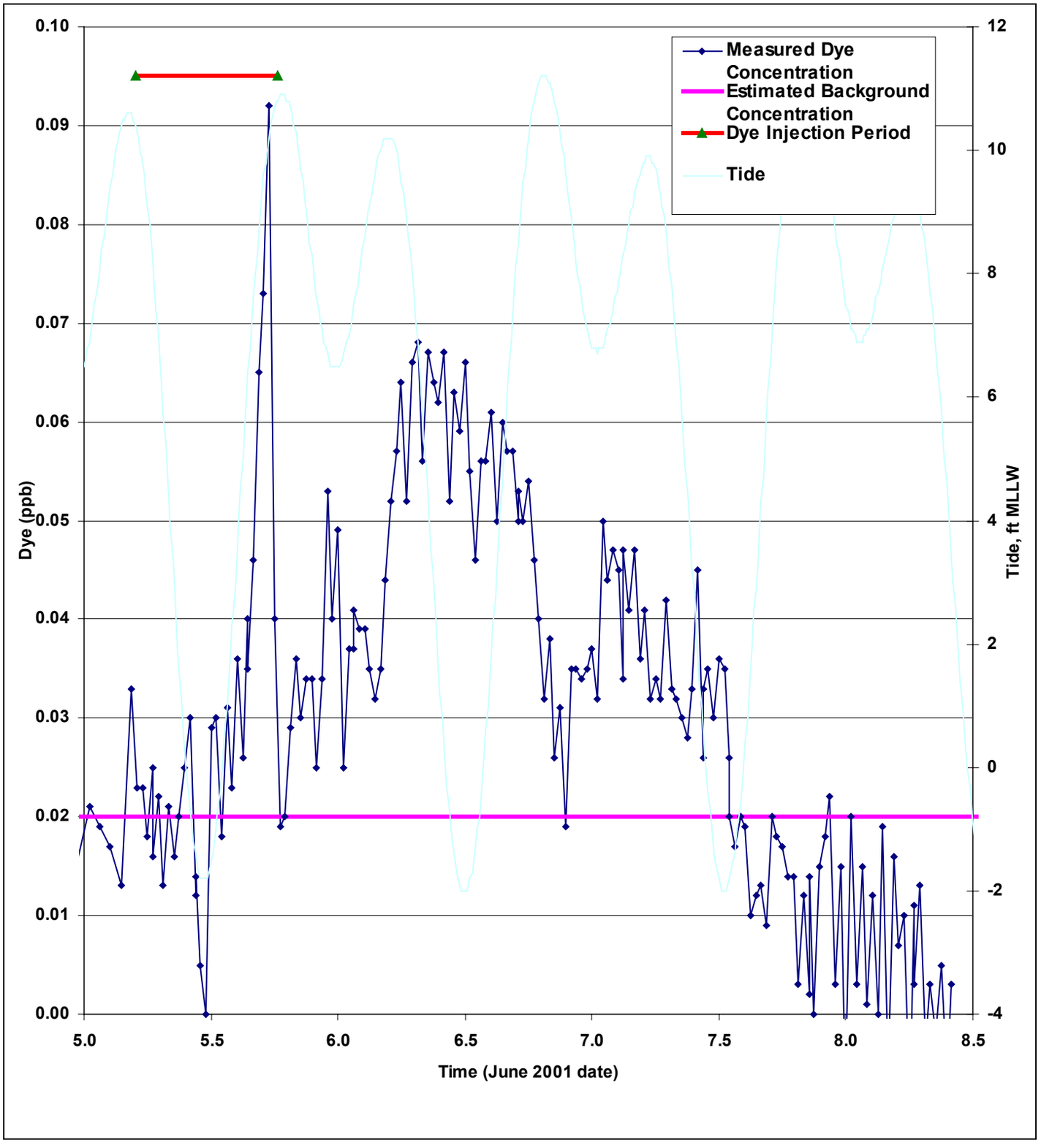
Seven drogues were deployed at 3-13 m during the first dye release experiment off Browns Bay in February 2001. Deployments were at about 1-hr intervals (starting with drogue #1) during a large ebb tide followed by a large flood tide.

Figure 55. **Dye sampled near shore during Dye Study 3**



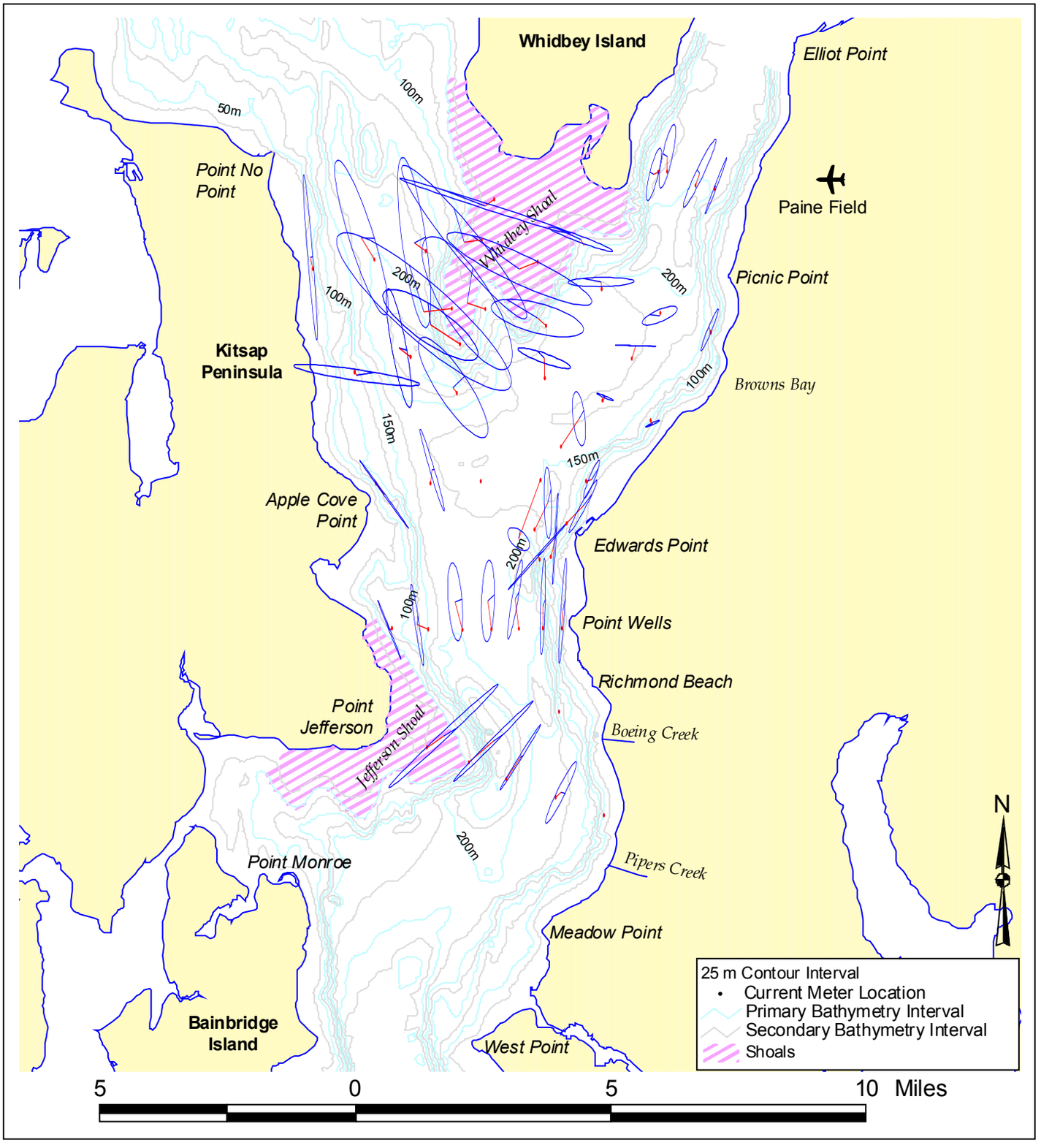
Dye concentration vs. time at the Meadowdale Marina from Dye Study 3. NOAA tidal predictions, based on sea level at Seattle.

Figure 56. **Dye sampled near shore during Dye Study 4**



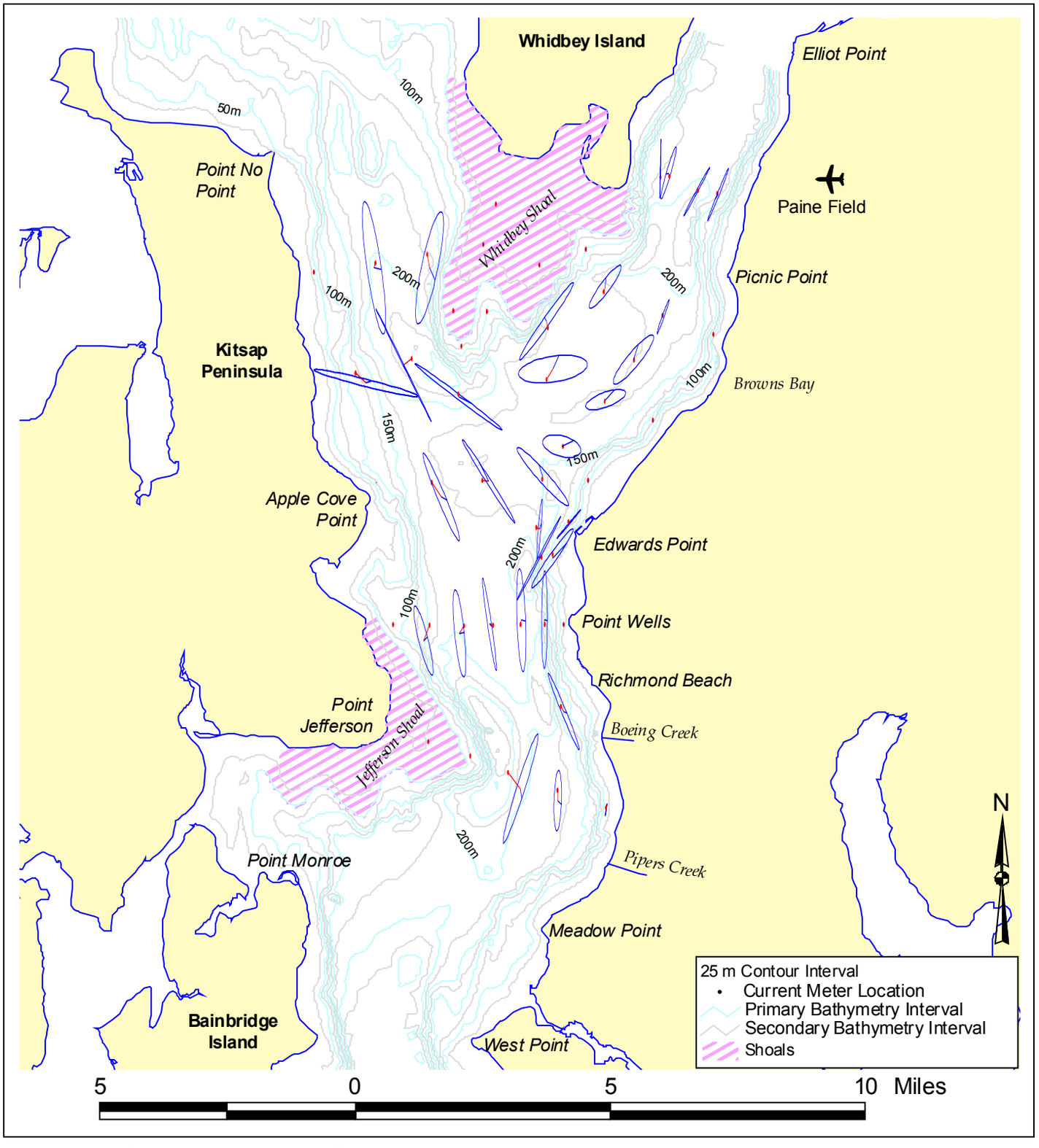
Dye concentration vs. time at the Edmonds station from Dye Study 4. NOAA tidal predictions, based on sea level at Seattle.

Figure 57. **M2 tidal ellipses: 20-40 m**



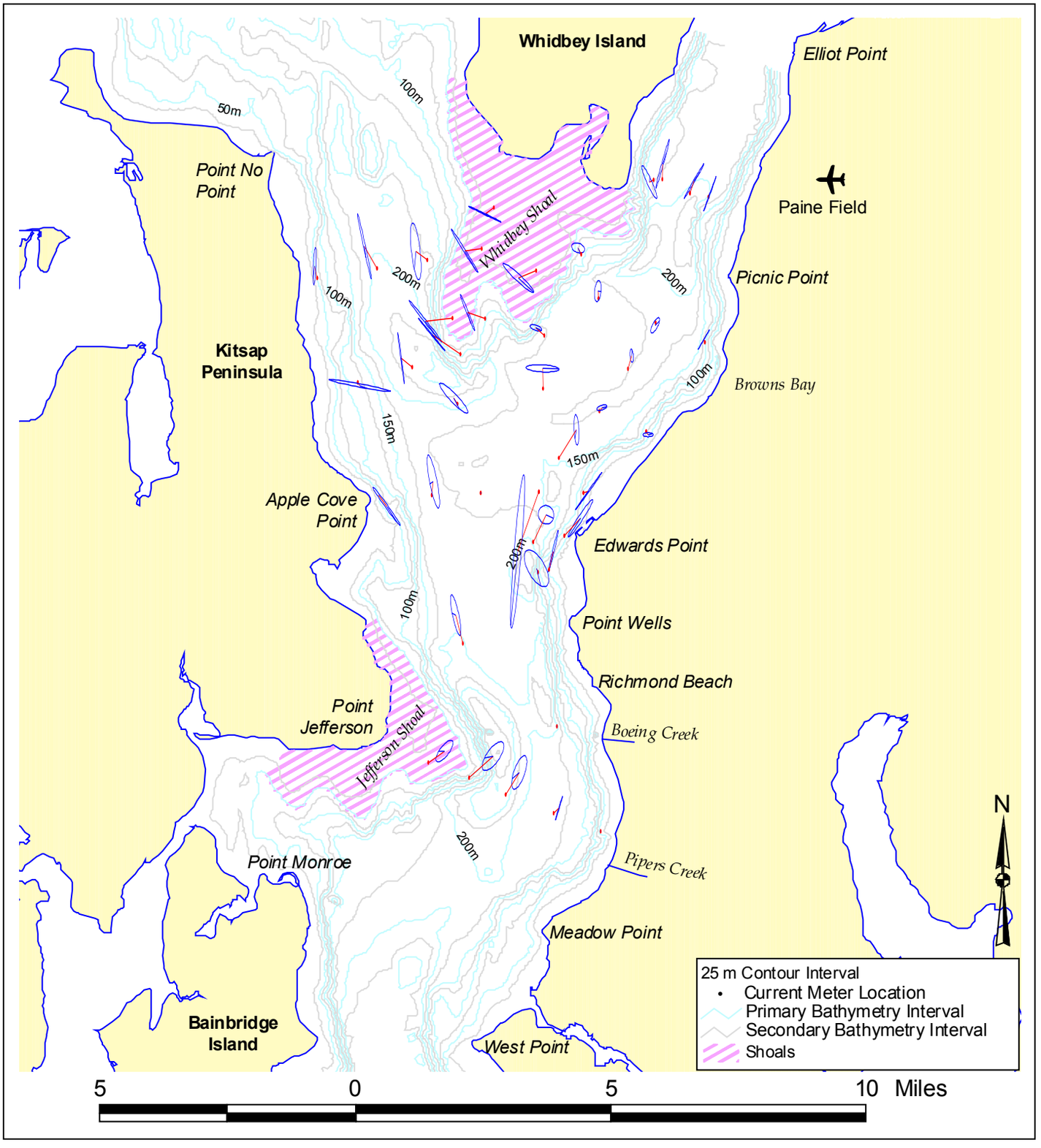
M2 ellipses for currents averaged from 20-40 m.

Figure 58. **M2 tidal ellipses: 100-120 m**



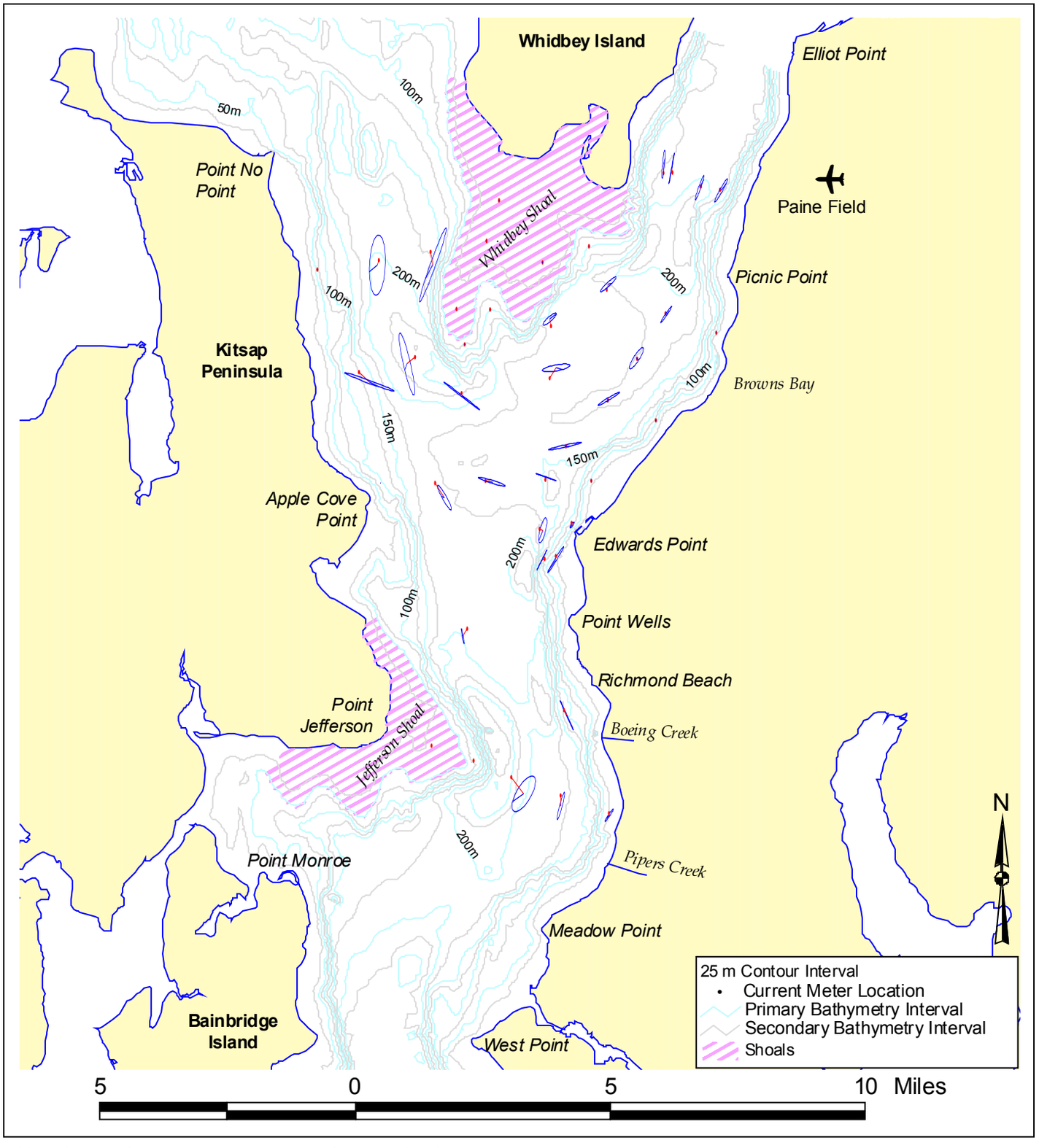
M2 ellipses for currents averaged from 100-120 m.

Figure 59. **K1 tidal ellipses: 20-40 m**



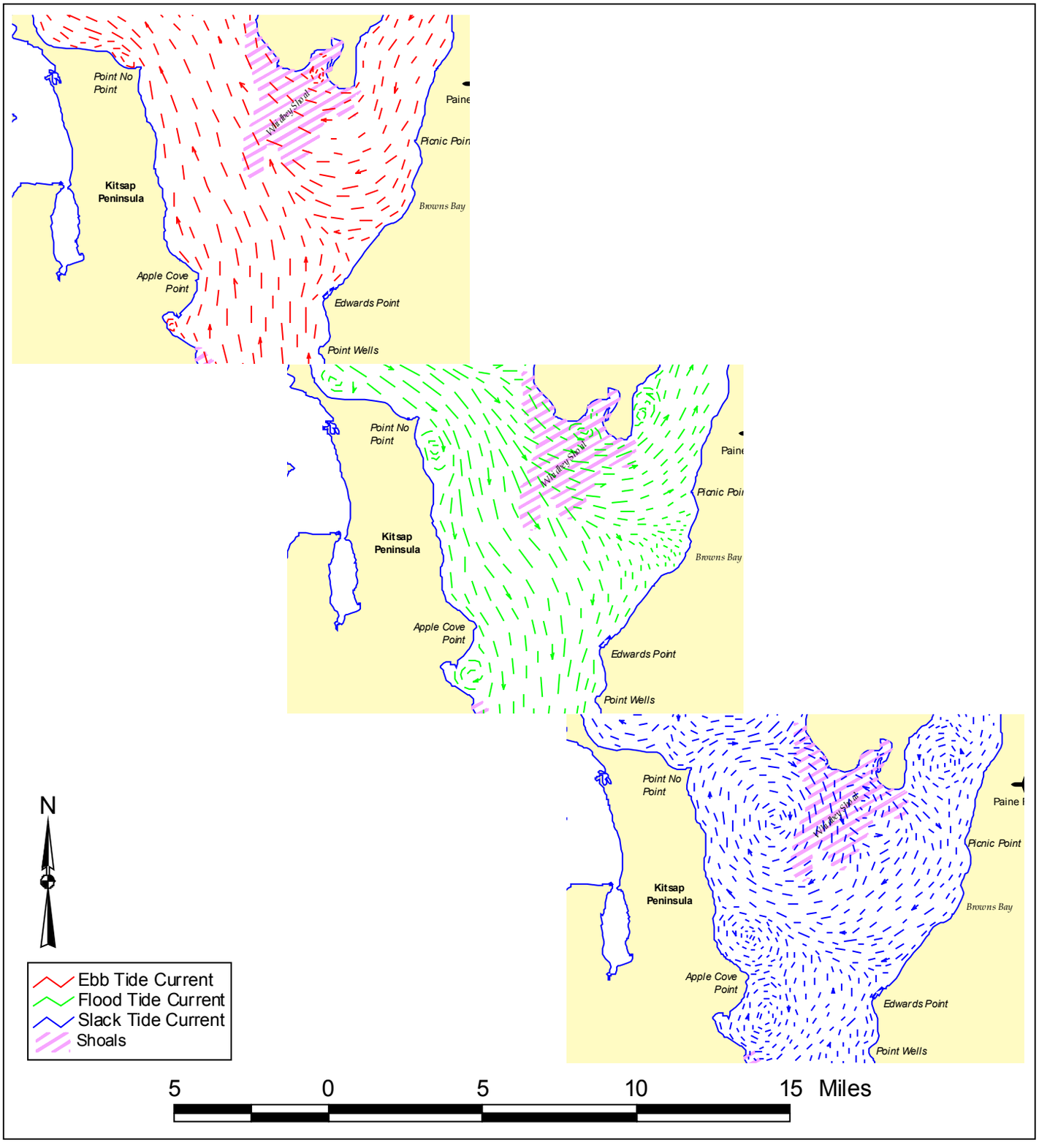
K1 ellipses for currents averaged from 20-40 m.

Figure 60. **K1 tidal ellipses: 100-120 m**



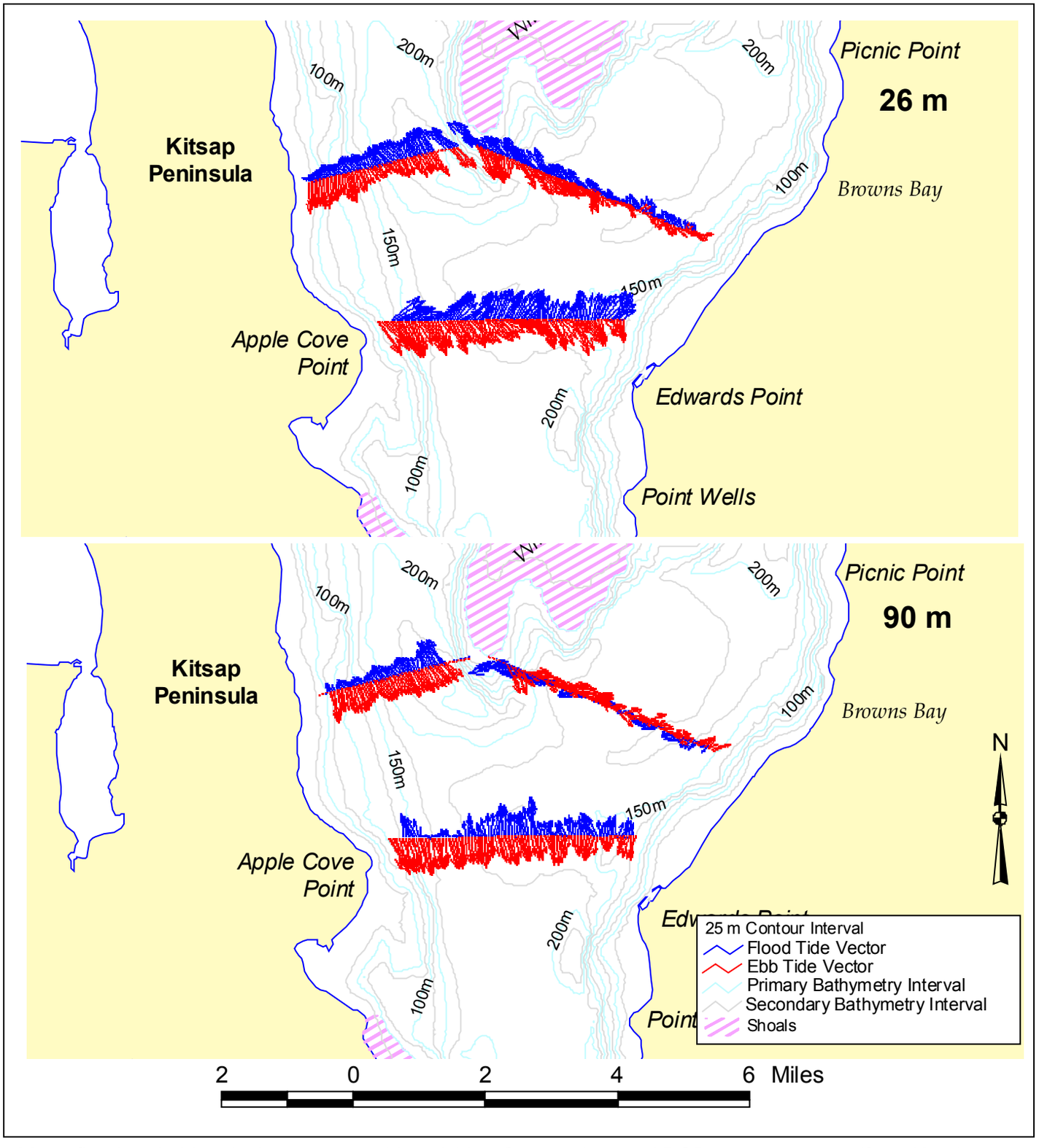
K1 ellipses for currents averaged from 100-120 m.

Figure 61. **Hydraulic model surface tidal currents**



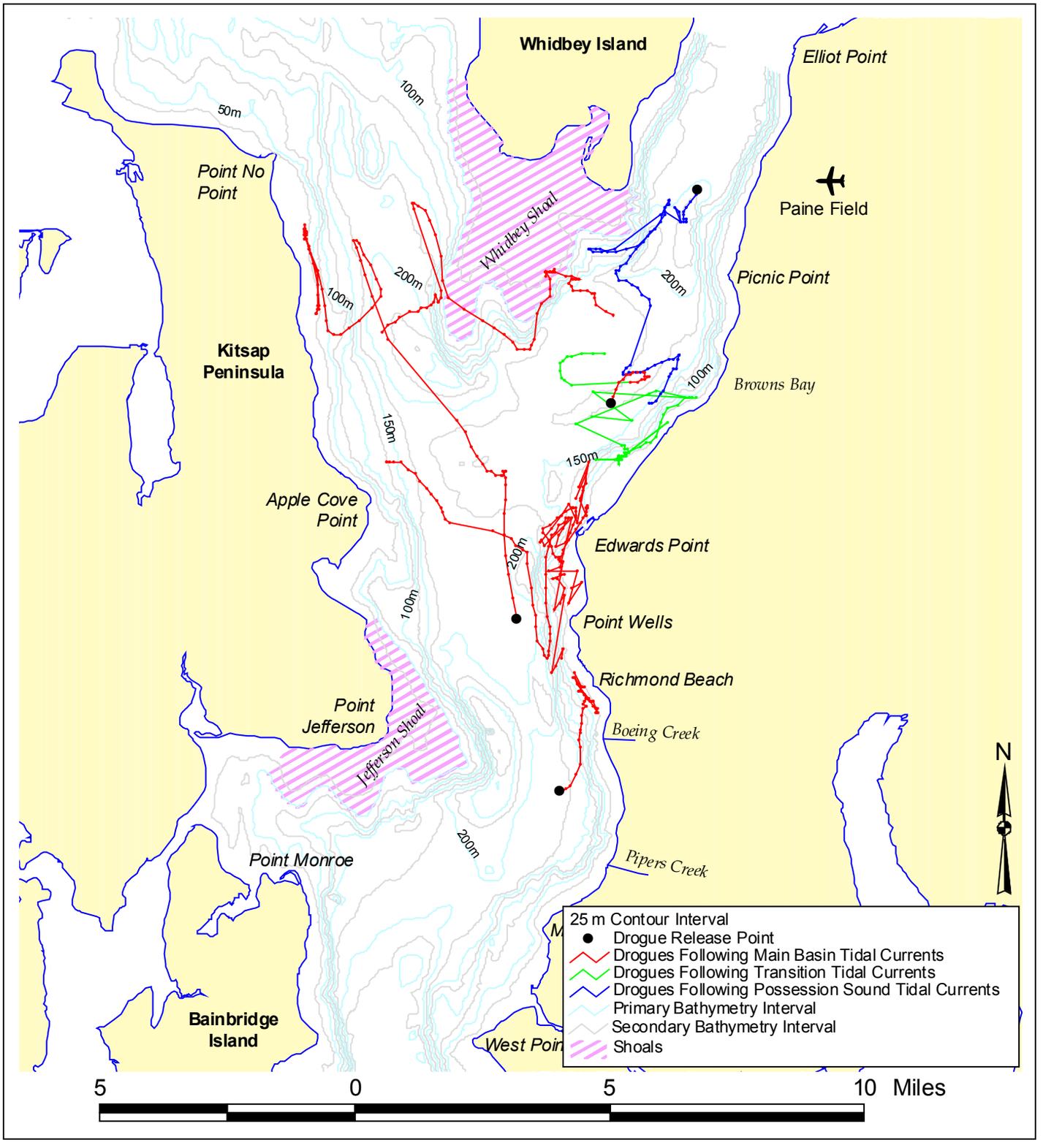
Flow patterns in the Triple Junction (from McGary and Lincoln, 1977). Stages of the tide: Top panel is a large ebb current; middle, large flood; and bottom, high water after large flood. Hatching shows Whidbey Shoal.

Figure 62. **Shipboard ADCP tidal currents**



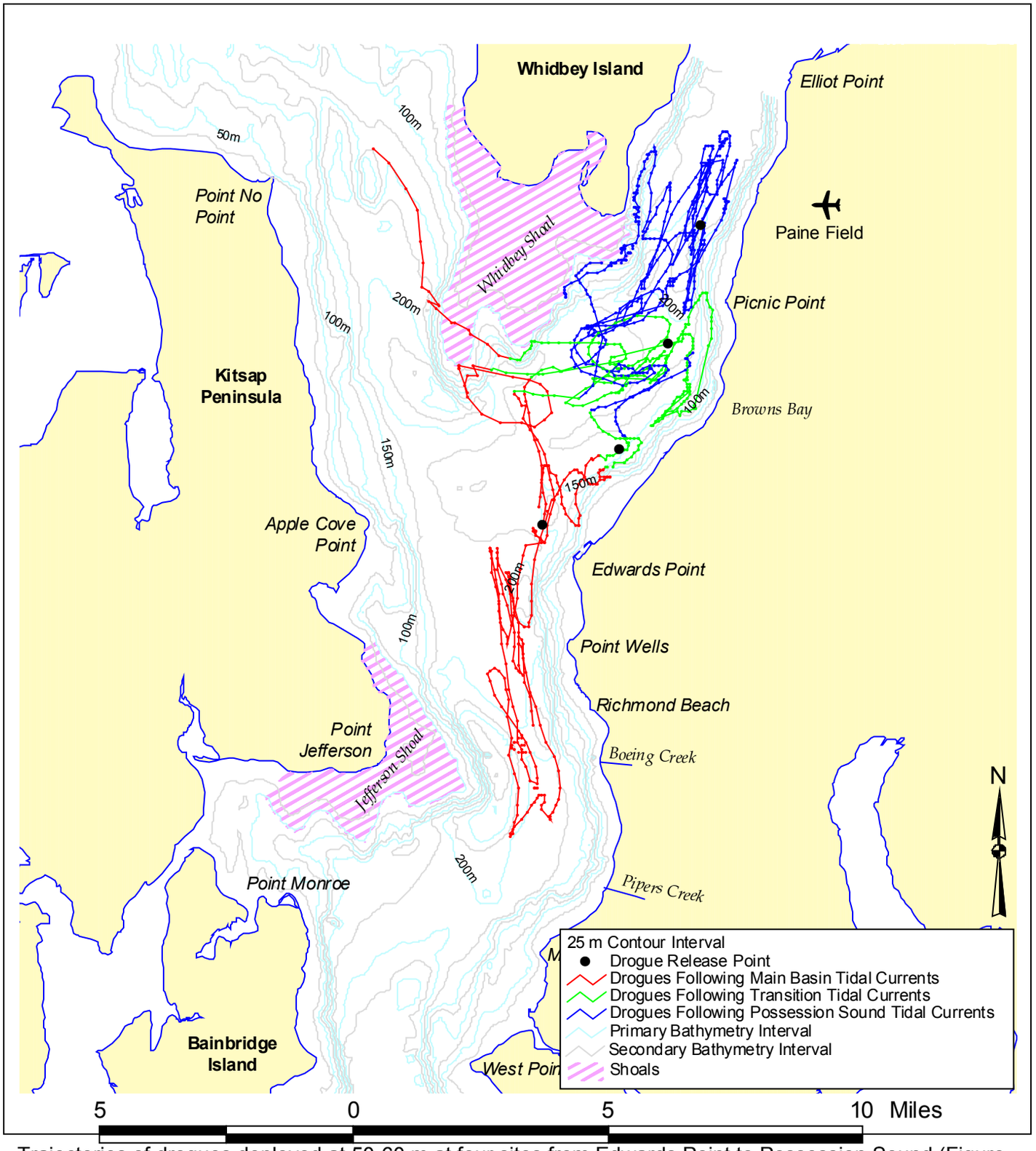
Mean flood and ebb velocity vectors at 26 and 90 m from underway ADCP measurements (from Kende, 2001). Note the flow is roughly parallel to the northeast transit.

Figure 63. **Tidal effects on drogue Deployment E: 25 m**



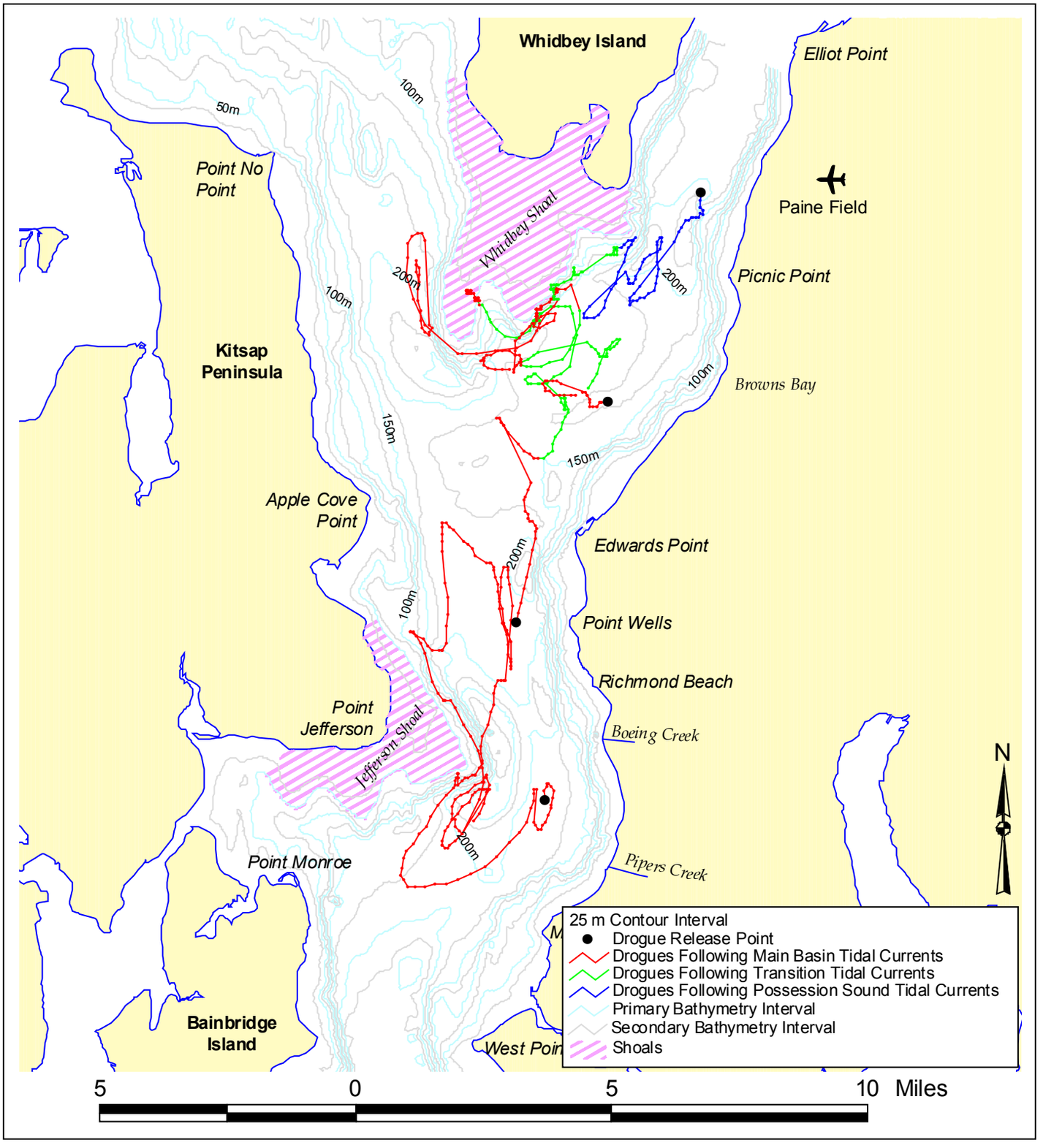
Trajectories of drogues deployed at 20-30 m at the four offshore drift card sites (Figs. 3, 4). Trajectories follow currents in the Main Basin (red), Possession Sound (blue) or neither (green).

Figure 64. **Tidal effects on drogue Deployment F: 55 m**



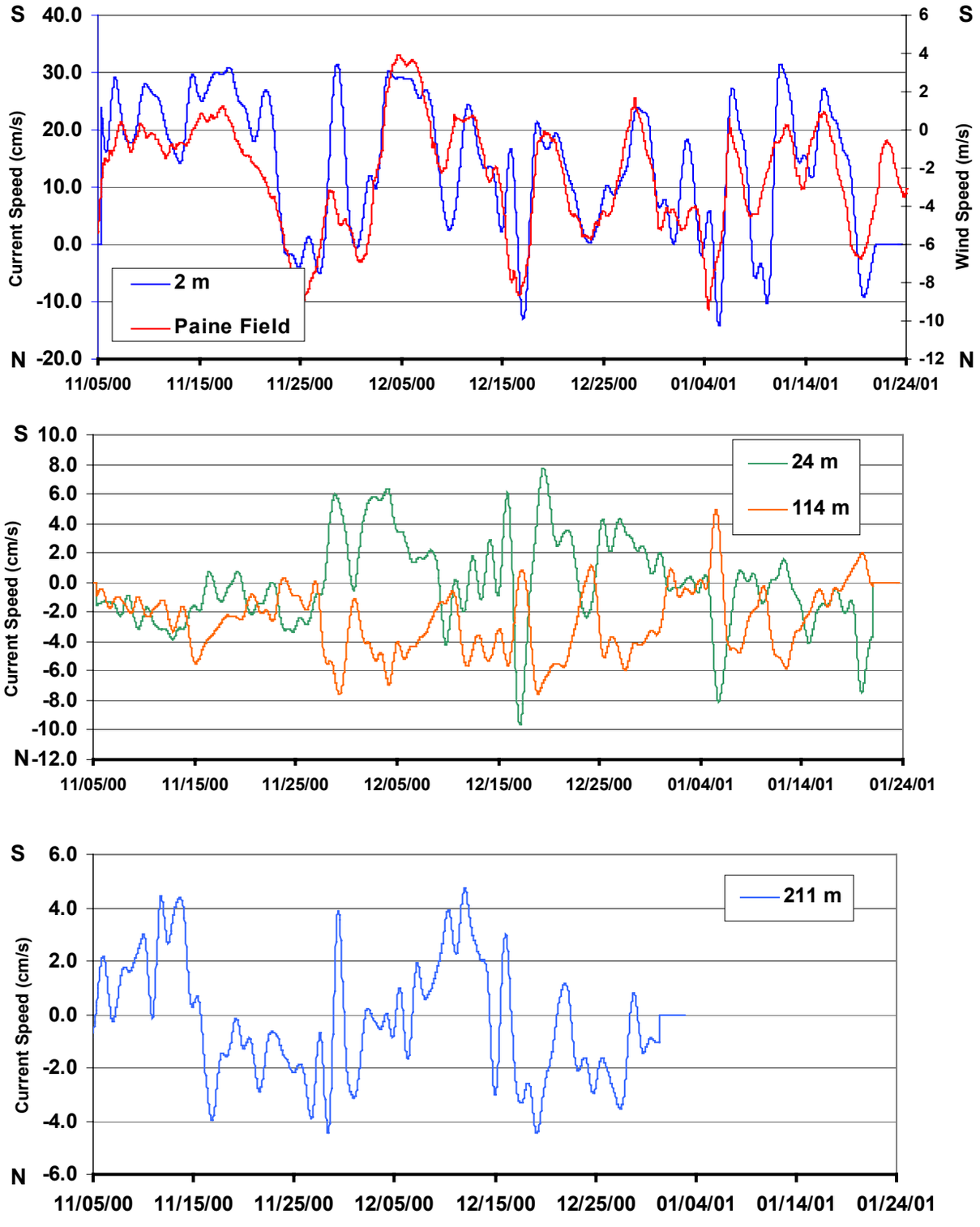
Trajectories of drogues deployed at 50-60 m at four sites from Edwards Point to Possession Sound (Figure 4). Trajectories follow currents in the Main Basin (red), Possession Sound (blue) or neither (green).

Figure 65. **Tidal effects on drogue Deployment E: 105 m**



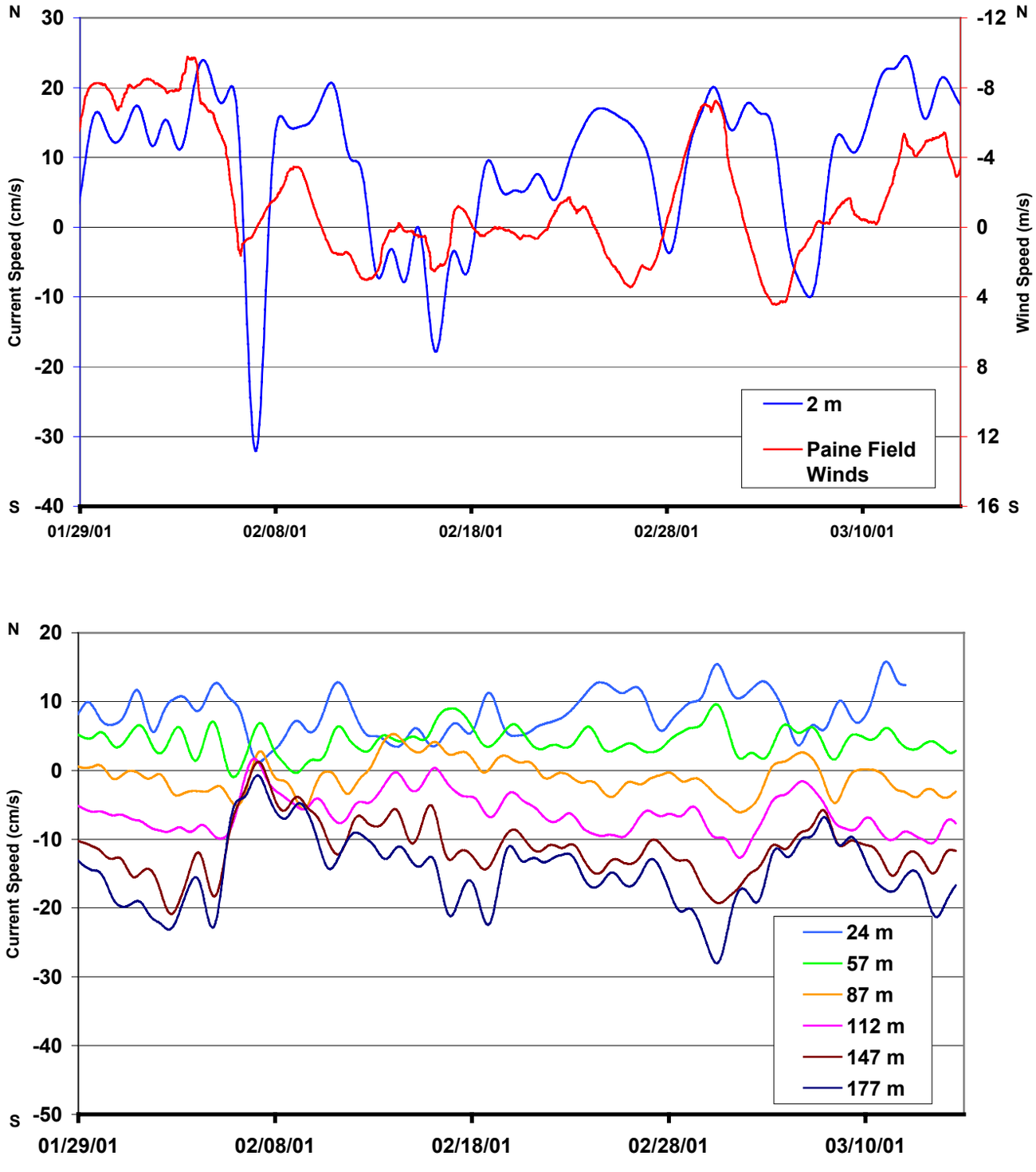
Trajectories of drogues deployed at 100-120 m at the northern three offshore drift card sites (Figs. 3, 4). Trajectories follow currents in the Main Basin (red), Possession Sound (blue) or neither (green).

Figure 66. **Currents and winds: Possession Sound**



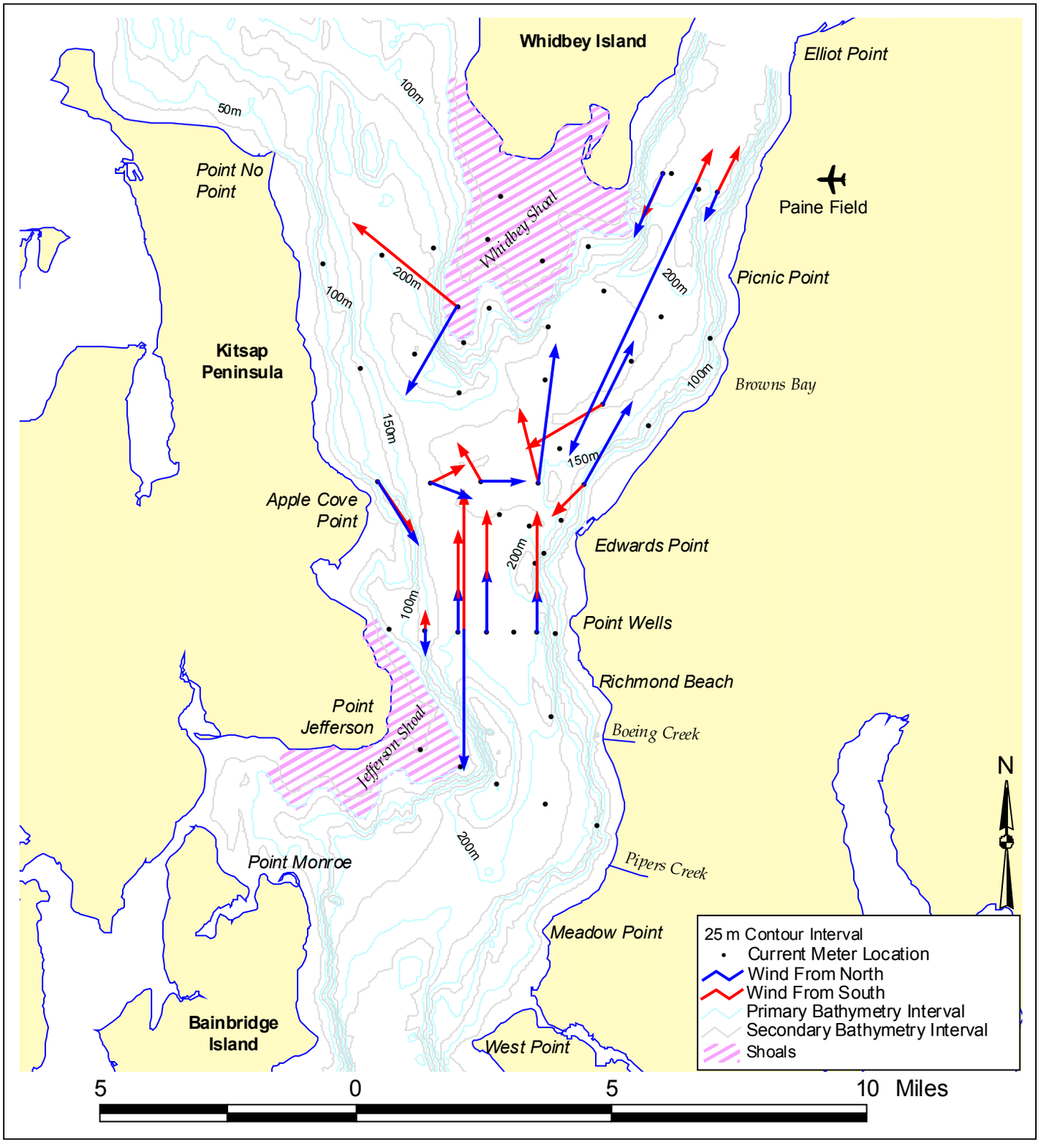
Along-channel 35-hr filtered currents and winds at the Possession Sound mooring during Deployment 3. An S4 current meter was at 2 m; Aanderaa's elsewhere. Winds were measured at Paine Field. Positive currents and winds are southward along channel; outflow is from Possession Sound into the Triple Junction. Mean current profiles for these data are in Figure 32.

Figure 67. **Currents and winds: Point Wells**



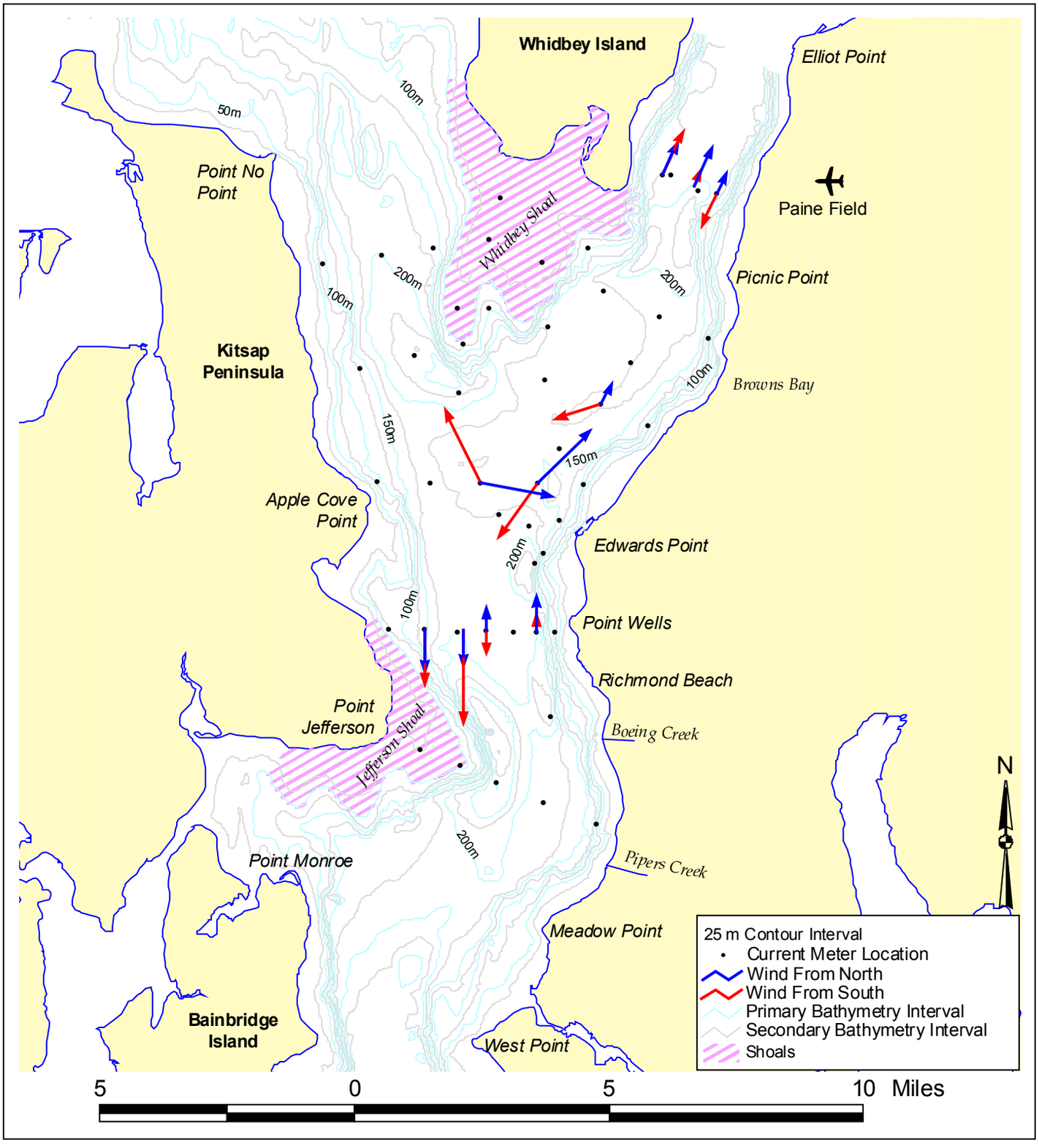
Along-channel 35-hr filtered currents and winds at the Main Basin reference mooring during Deployment 4. An S4 current meter was at 2 m; Aanderaa's elsewhere. Winds were measured at Paine Field. Positive currents are northward; outflow is from the Main Basin toward Admiralty Inlet. Mean current profiles for these data are in Figure 33. Dye 1 drogue deployment (Figure 54) was February 5-9.

Figure 68. **Wind effects on currents: near surface**



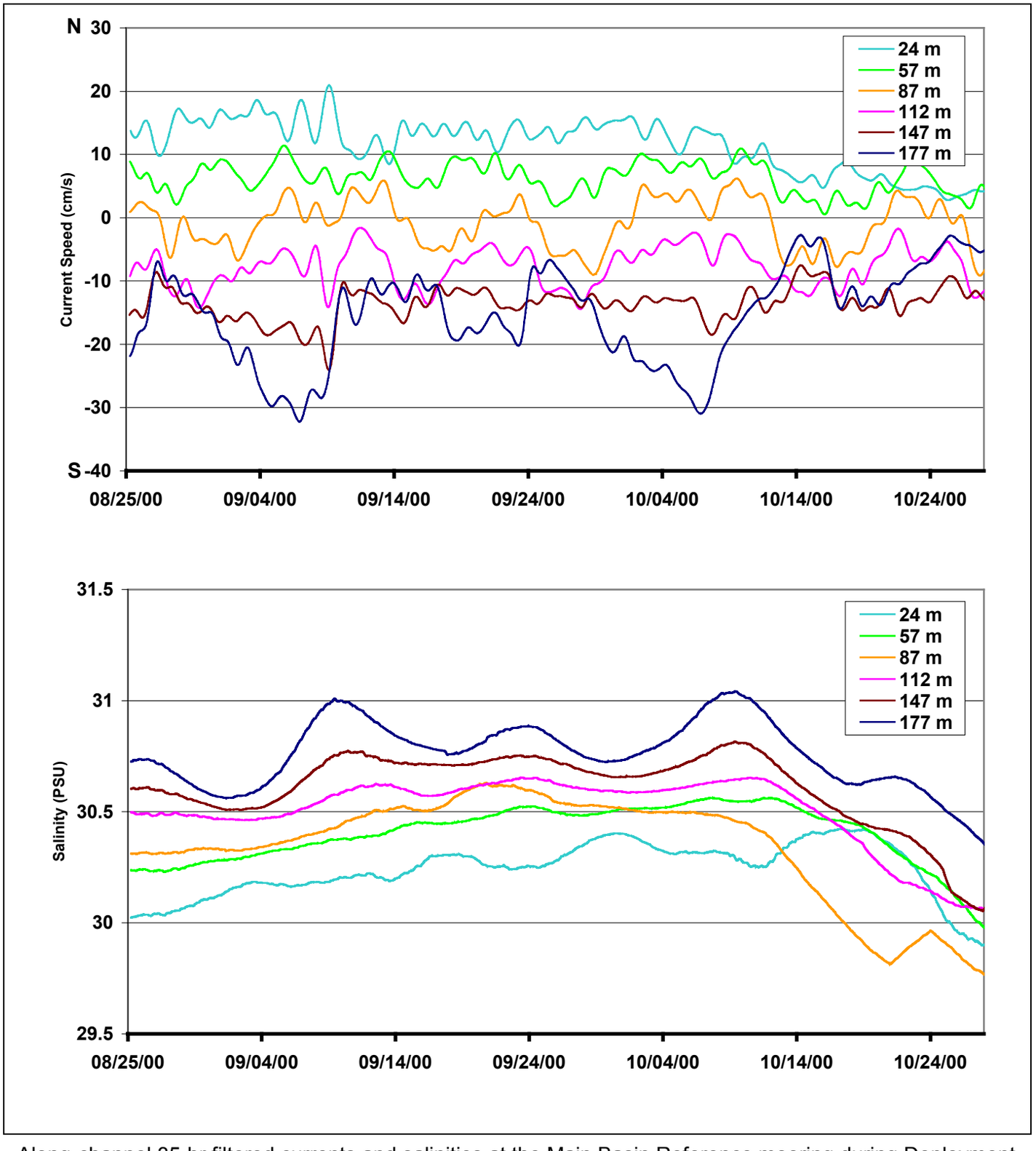
Schematic currents at 20 m during winds blowing from the south (red) and from the north (blue). Observations range from 2-40 m during Deployments 1-4.

Figure 69. **Wind effects on currents: mid depth**



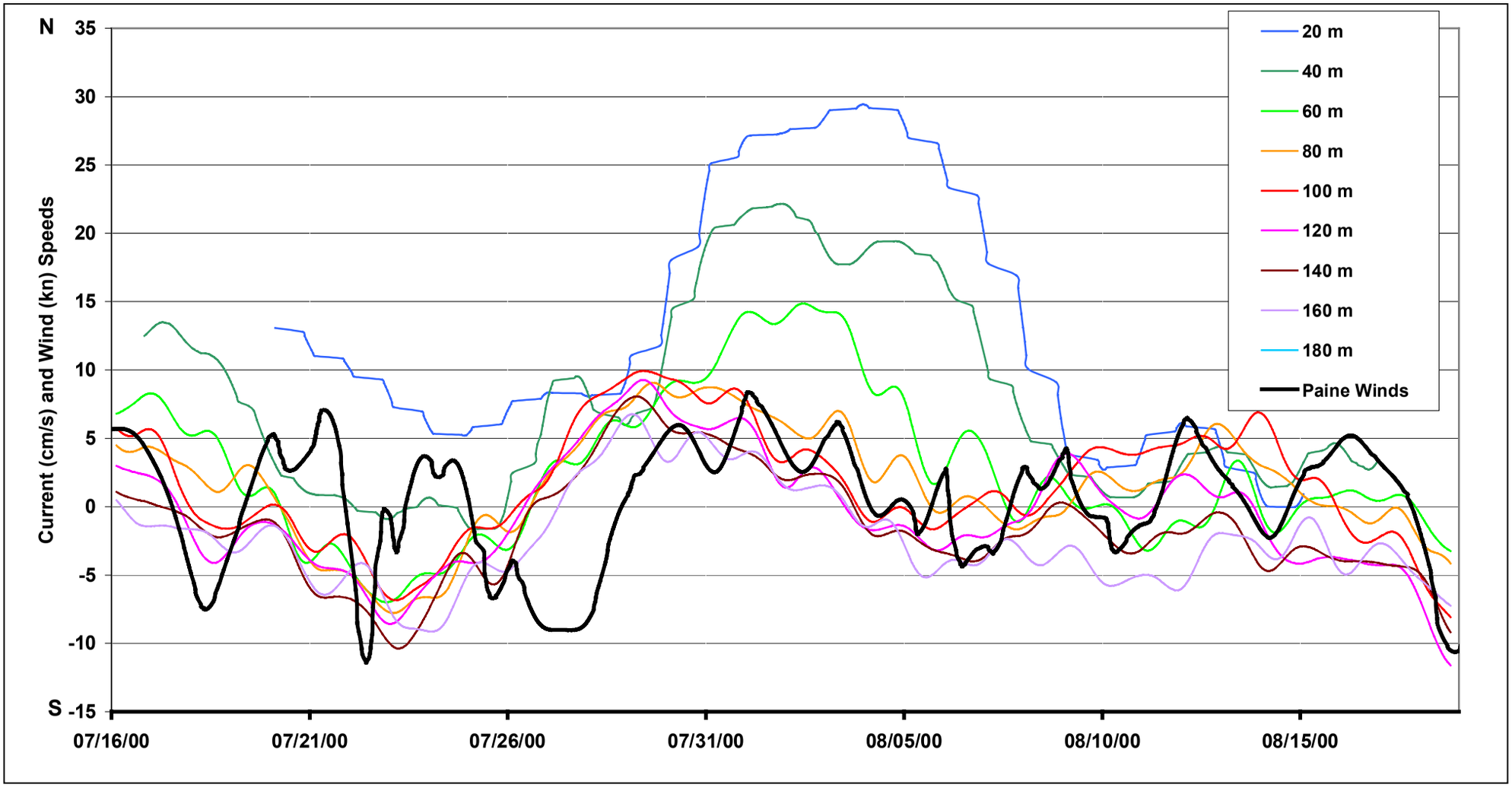
Schematic currents at 100 m during winds blowing from the south (red) and from the north (blue). Observations range from 80-115 m during Deployments 1-4.

Figure 70. **Intrusion currents and salinities: Point Wells**



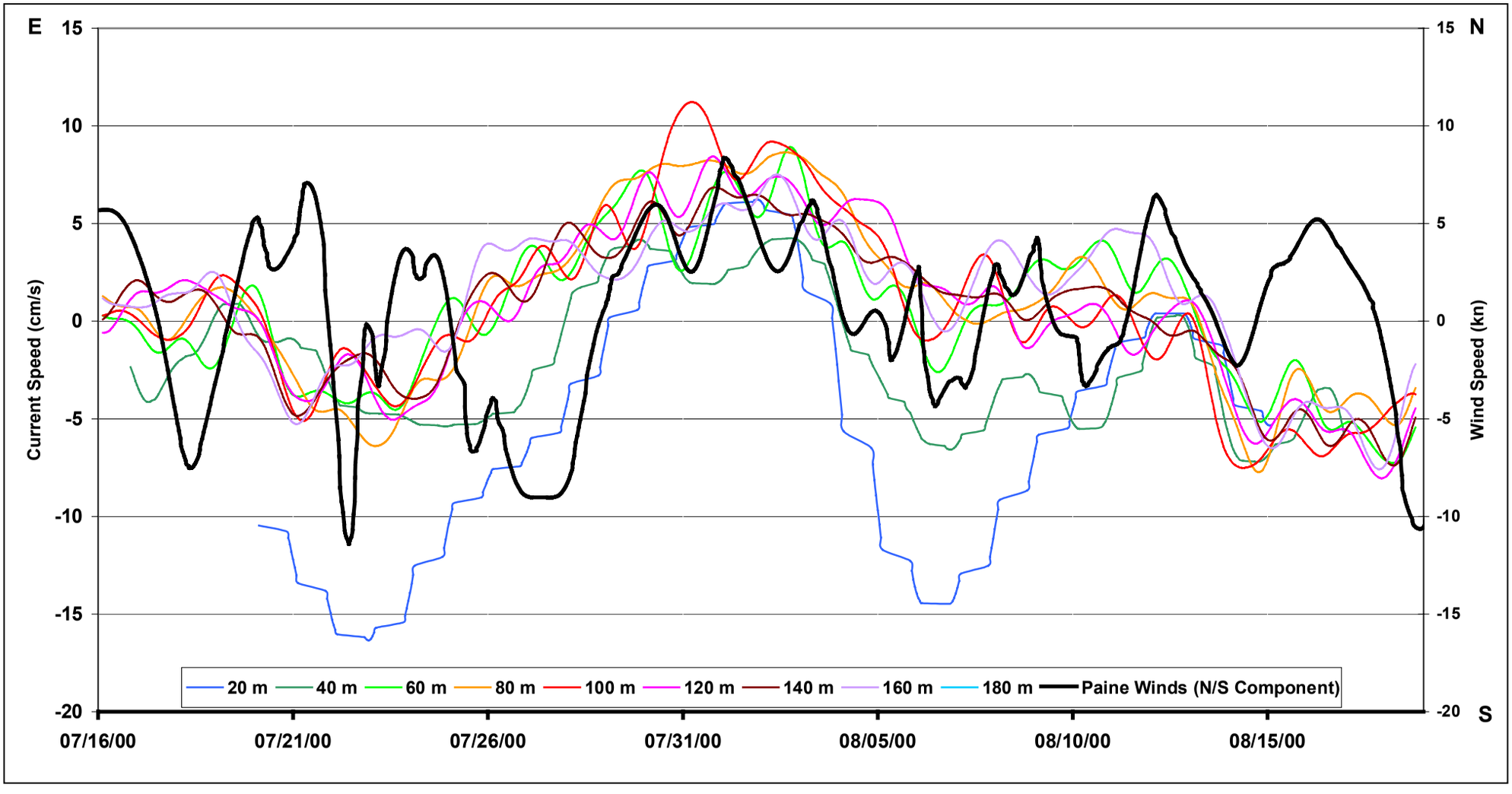
Along-channel 35-hr filtered currents and salinities at the Main Basin Reference mooring during Deployment 2. Salinity sensors used factory calibrations; salinities at 147 and 177 m are arbitrarily offset for ease in seeing relative changes.

Figure 71. **Low-frequency currents: Mooring 4**



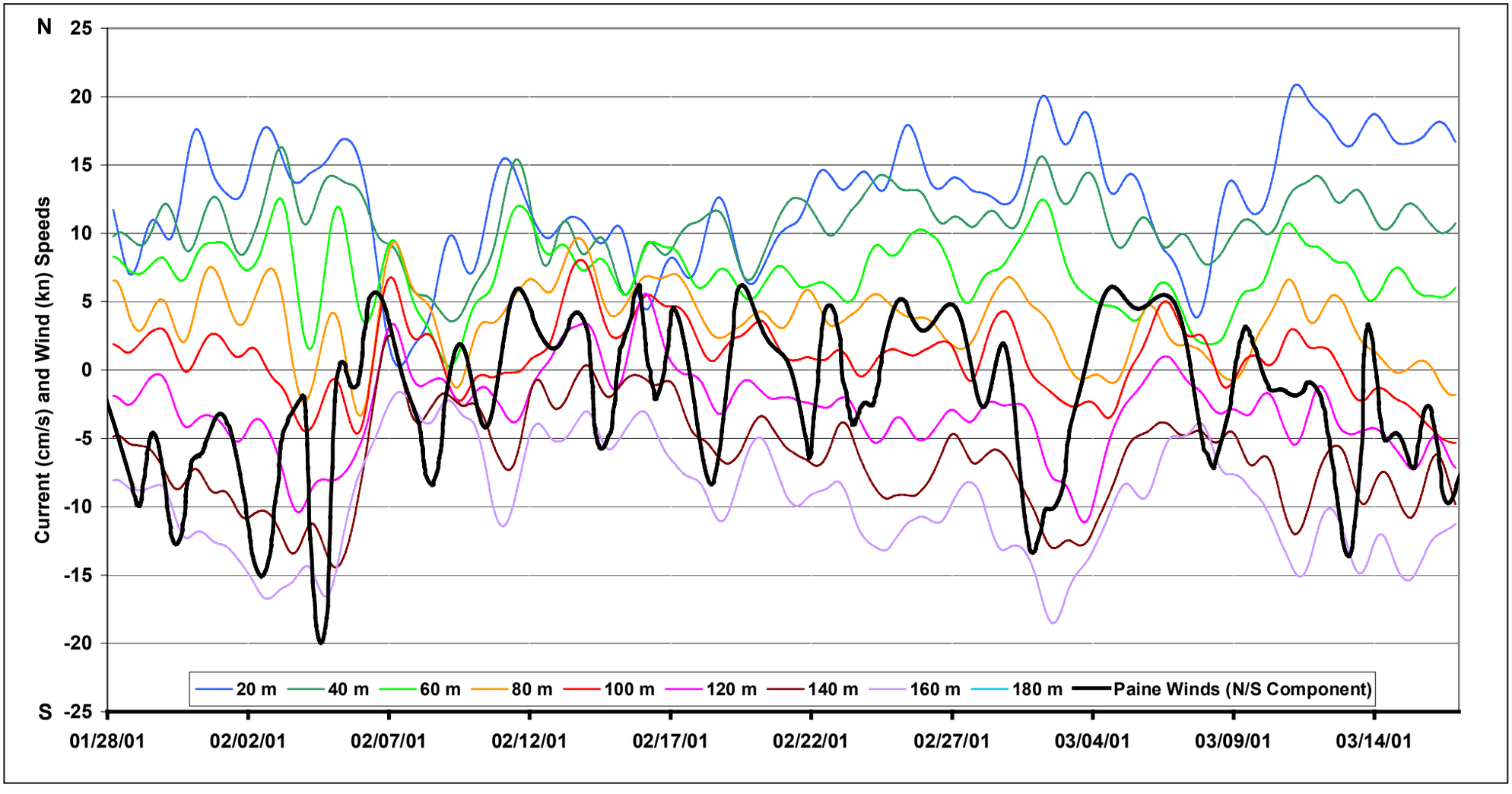
North-south time series at Mooring 4 during Deployment 1, and north-south winds (black) at Paine Field. Filter was 35-hr Lanczos. Positive currents are northward (oceanographic usage), and positive winds are northerly (from the north, meteorologic usage).

Figure 72. **Low-frequency currents: Mooring 4**



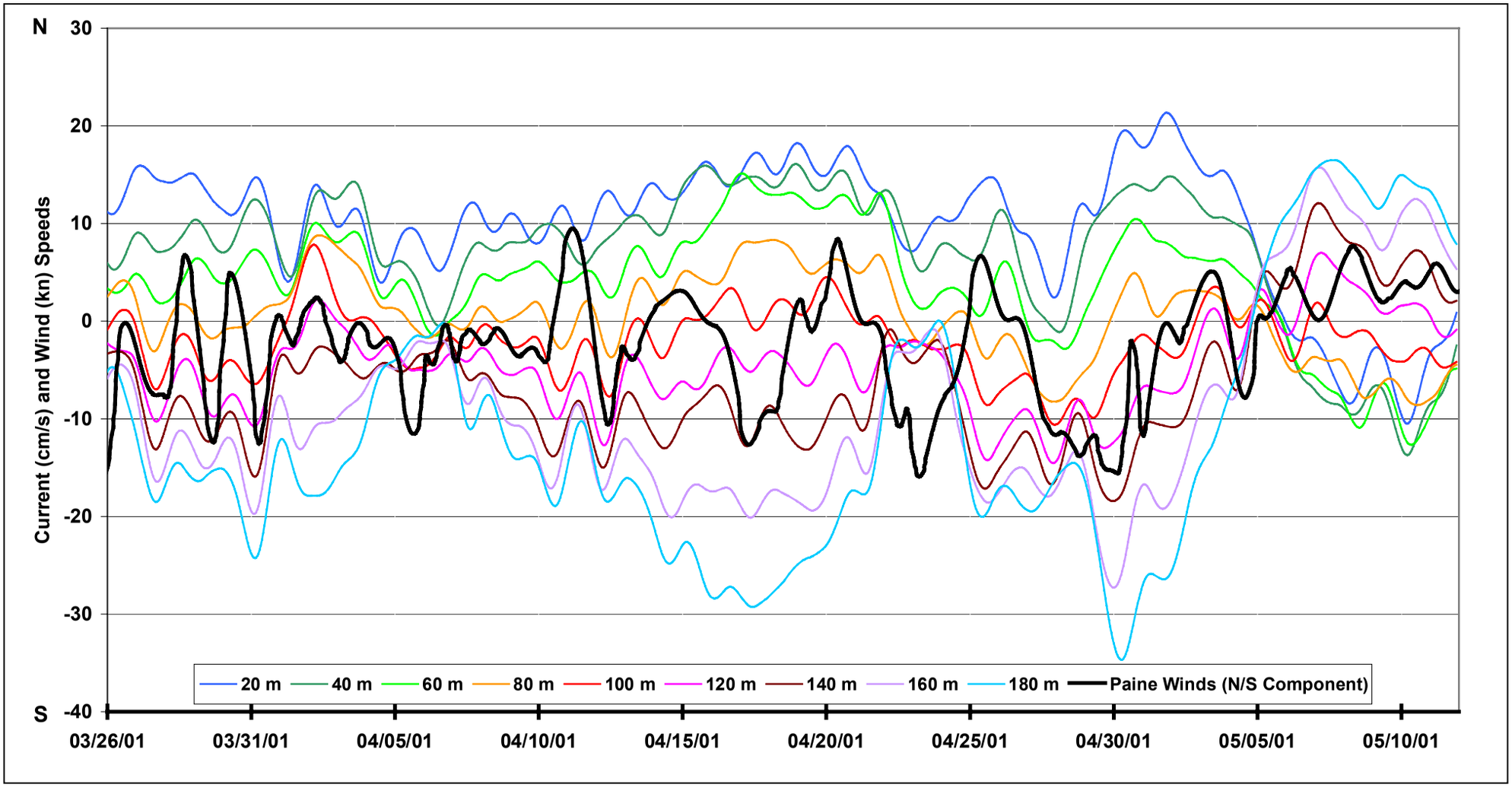
East-west time series at Mooring 4 during Deployment 1, and north-south winds (black) at Paine Field. Filter was 35-hr Lanczos. Positive currents are eastward (oceanographic usage), and positive winds are northerly (from the north, meteorologic usage).

Figure 73. **Low-frequency currents: Mooring 21**



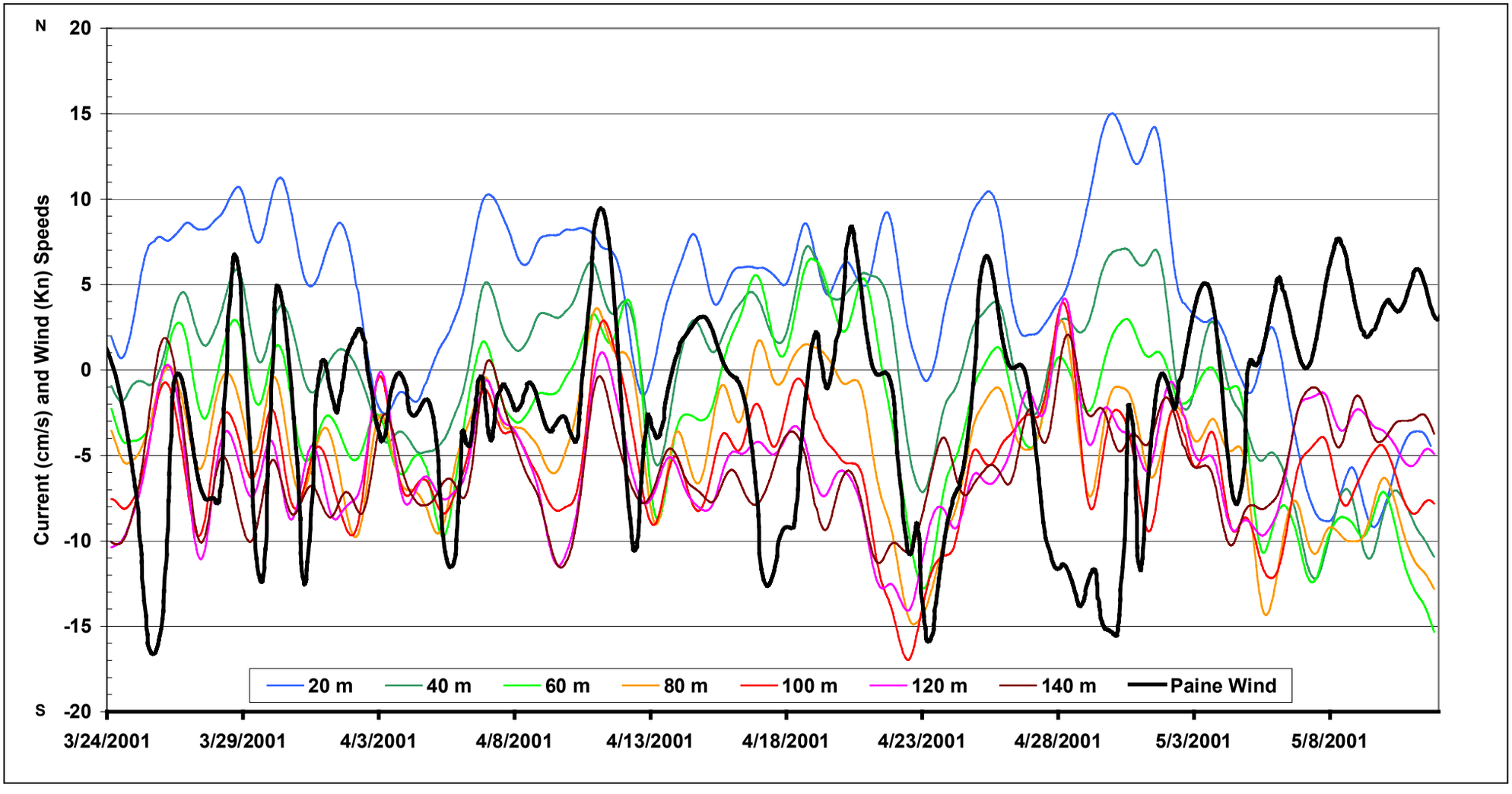
North-south (northward) time series at Mooring 21 during Deployment 4, and north-south winds (black) at Paine Field. Filter was 35-hr Lanczos. Positive currents are northward (oceanographic usage), and positive winds are northerly (from the north, meteorologic usage).

Figure 74. **Low-frequency currents: Mooring 31**



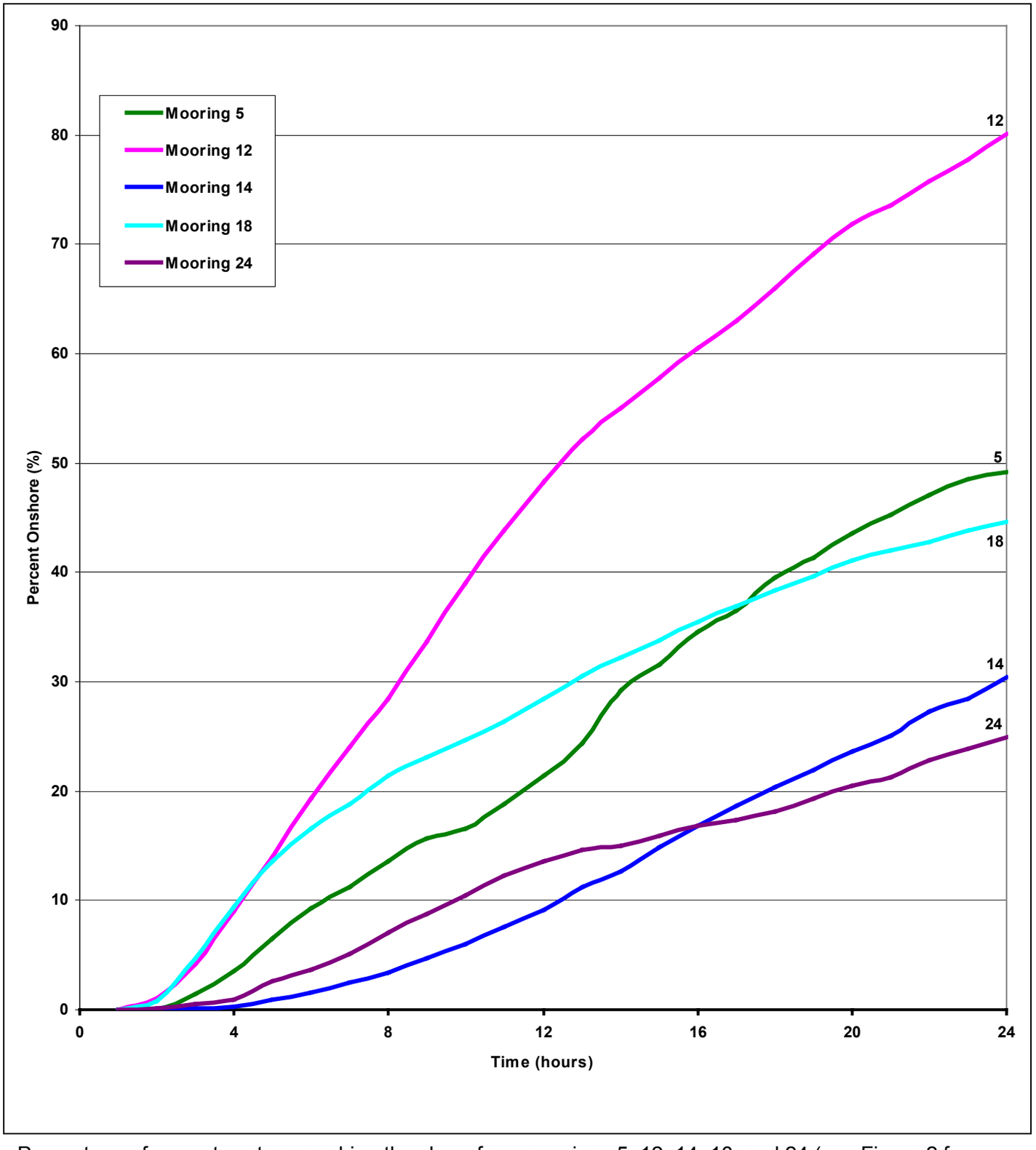
North-south time series at Mooring 31 during Deployment 5, and north-south winds (black) at Paine Field. Filter was 35-hr Lanczos. Positive currents are northward (oceanographic usage), and positive winds are northerly (from the north, meteorologic usage).

Figure 75. **Low Frequency Currents: Mooring 32**



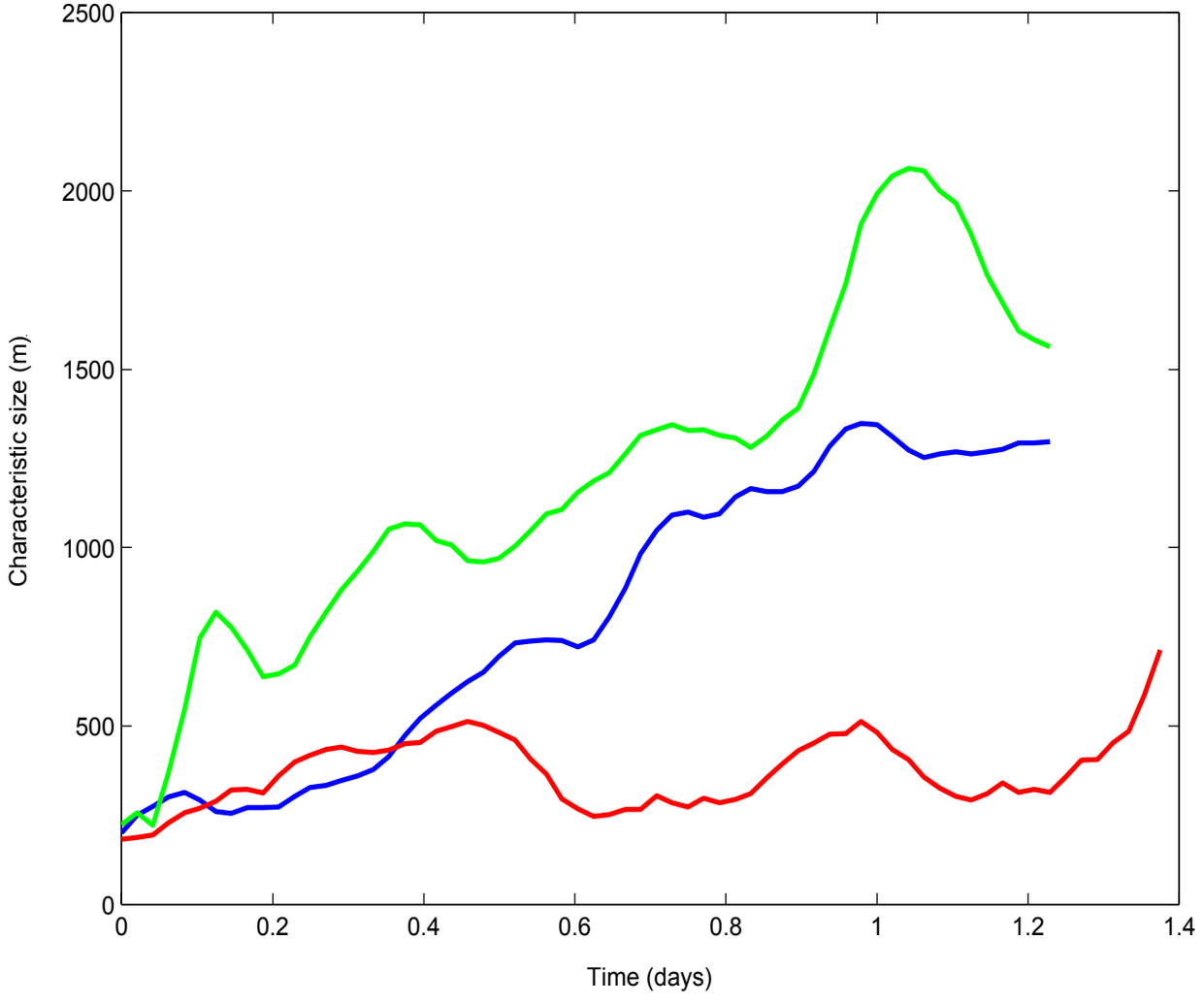
North-south time series at Mooring 32 during Deployment 5, and north-south winds (black) at Paine Field. Filter was 35-hr Lanczos. Positive currents are northward (oceanographic usage), and positive winds are northerly (from the north, meteorologic usage).

Figure 76. **Onshore currents: 20-40 m**



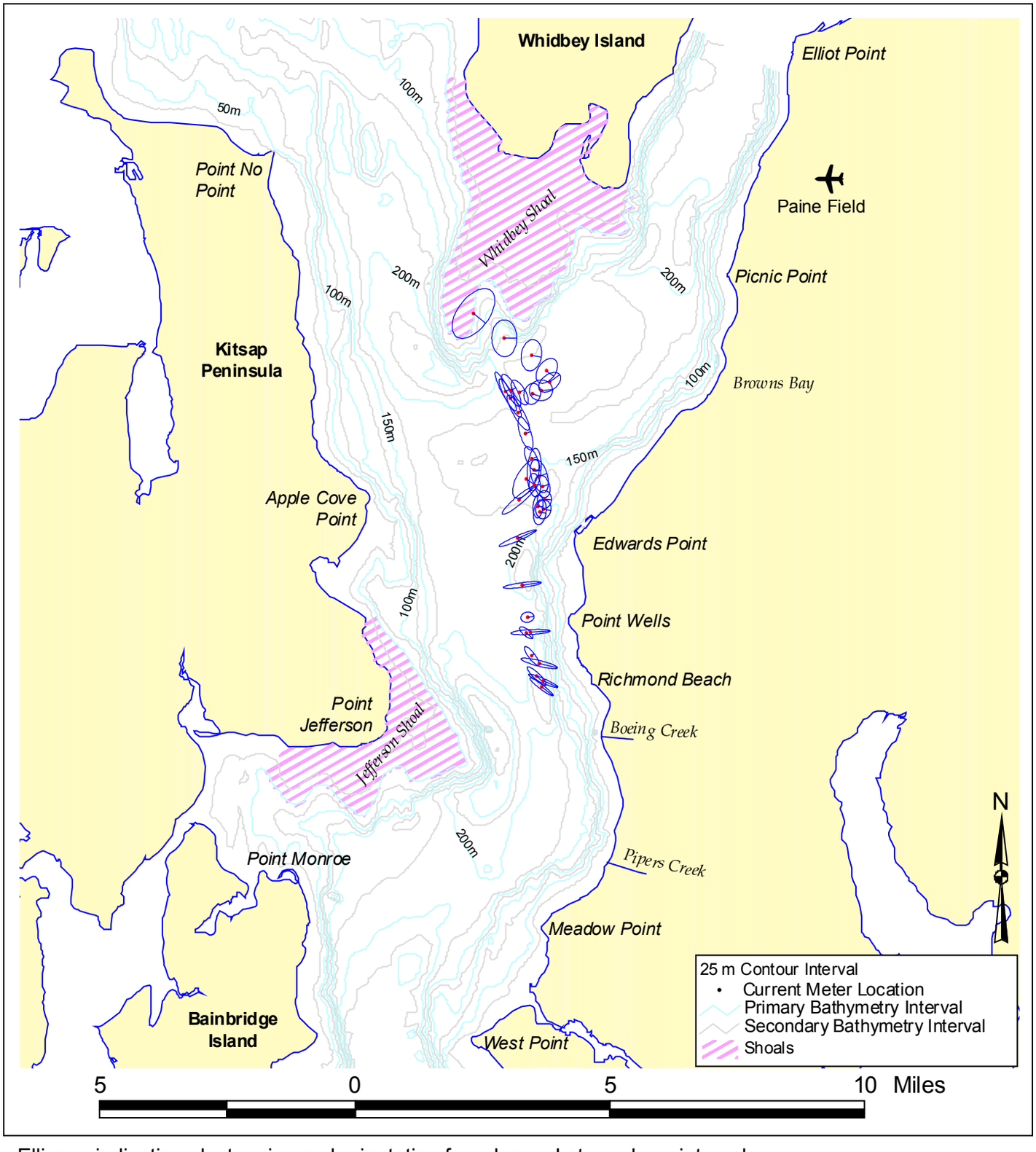
Percentage of current vectors reaching the shore from moorings 5, 12, 14, 18, and 24 (see Figure 2 for locations).

Figure 77. **Drogue cluster size**



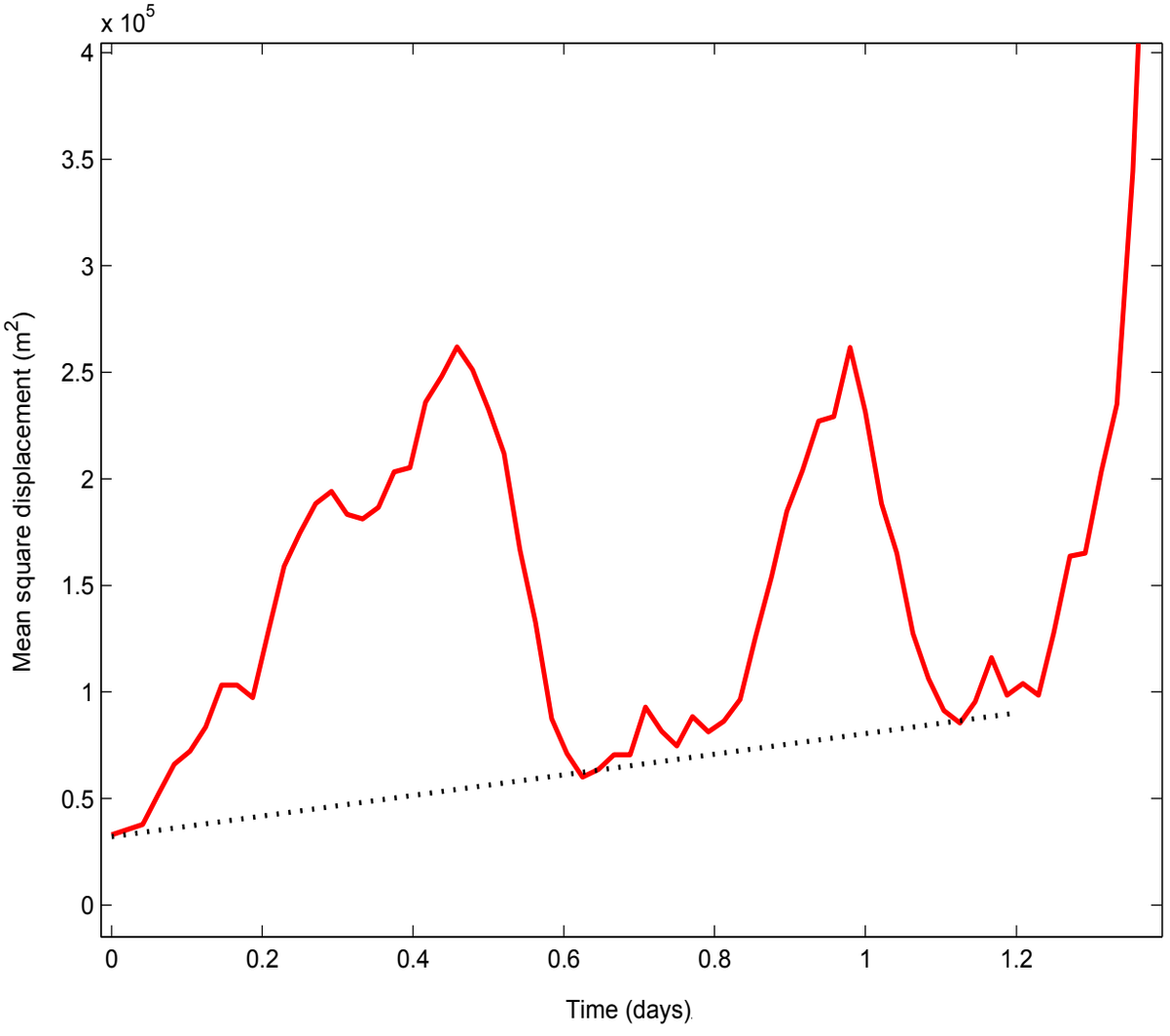
Drogue cluster size for release I (blue), J (red), and K (green).

Figure 78. **Drogue Release J cluster**



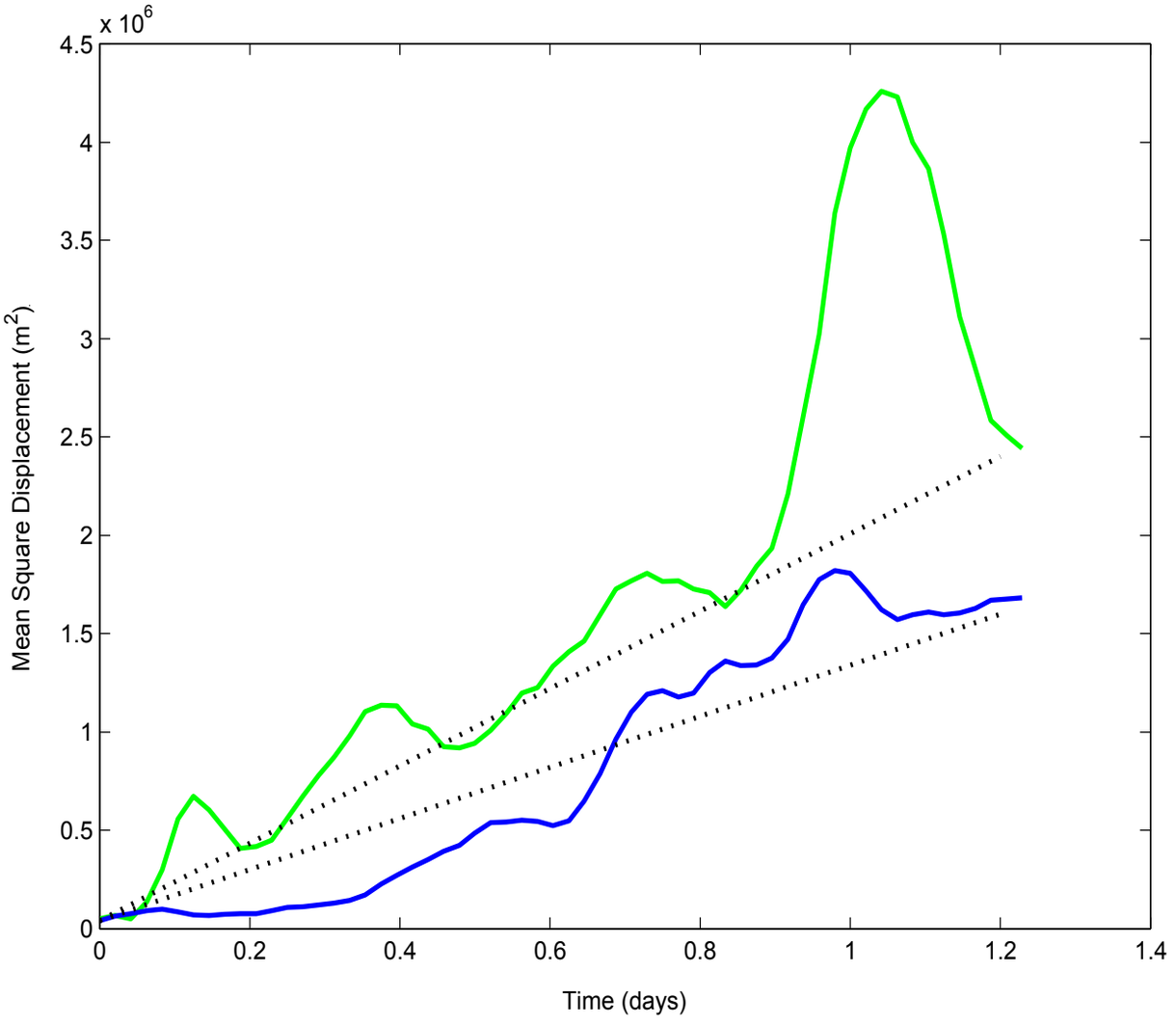
Ellipses indicating cluster size and orientation for release J at one-hour intervals.

Figure 79. **Drogue Release J cluster growth**



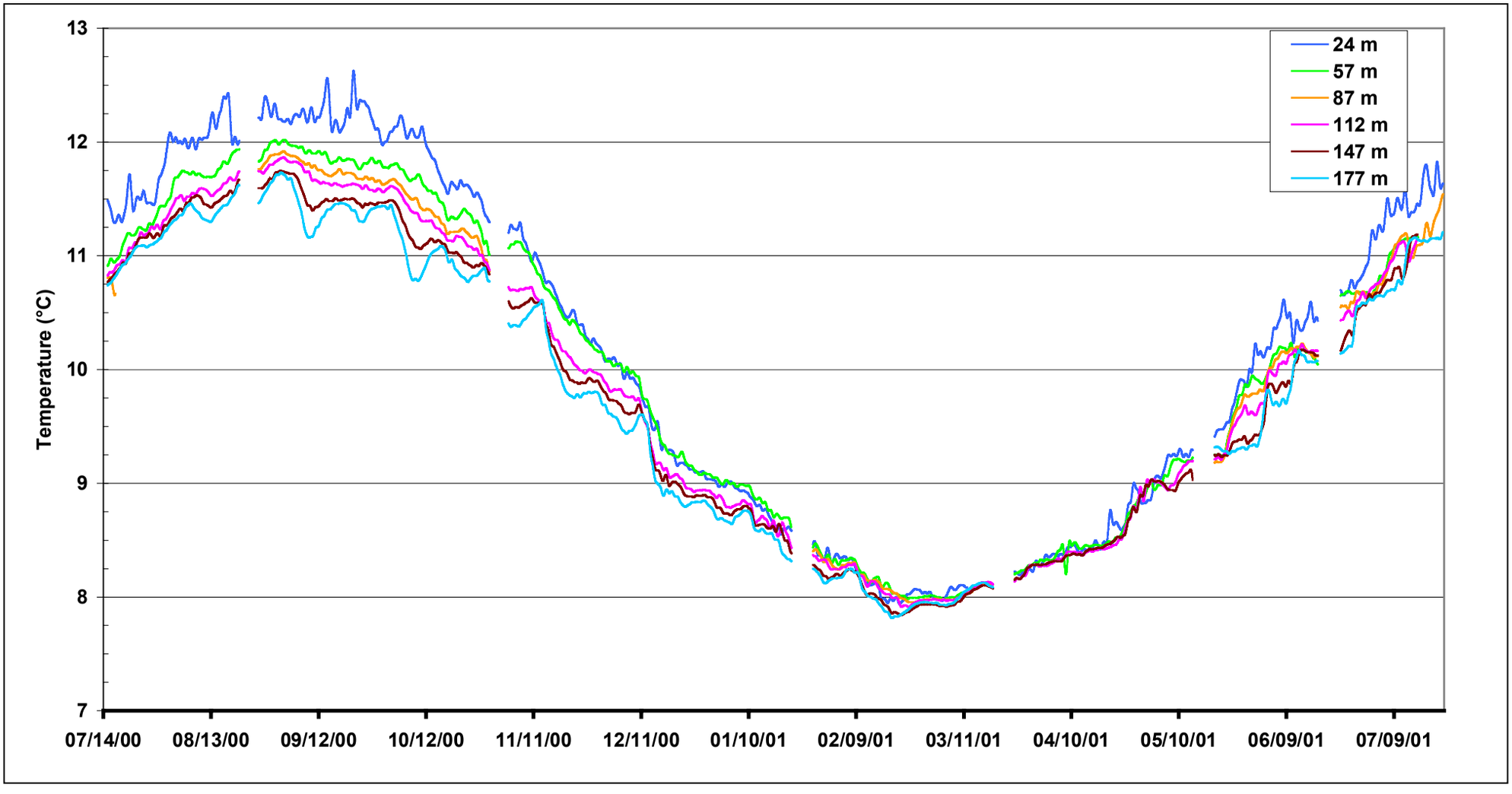
Mean square displacement for drogue release J. Dashed line indicates the rate used to estimate a dispersion coefficient of 2,800 cm^2/s.

Figure 80. **Drogue Releases I and K cluster growth**



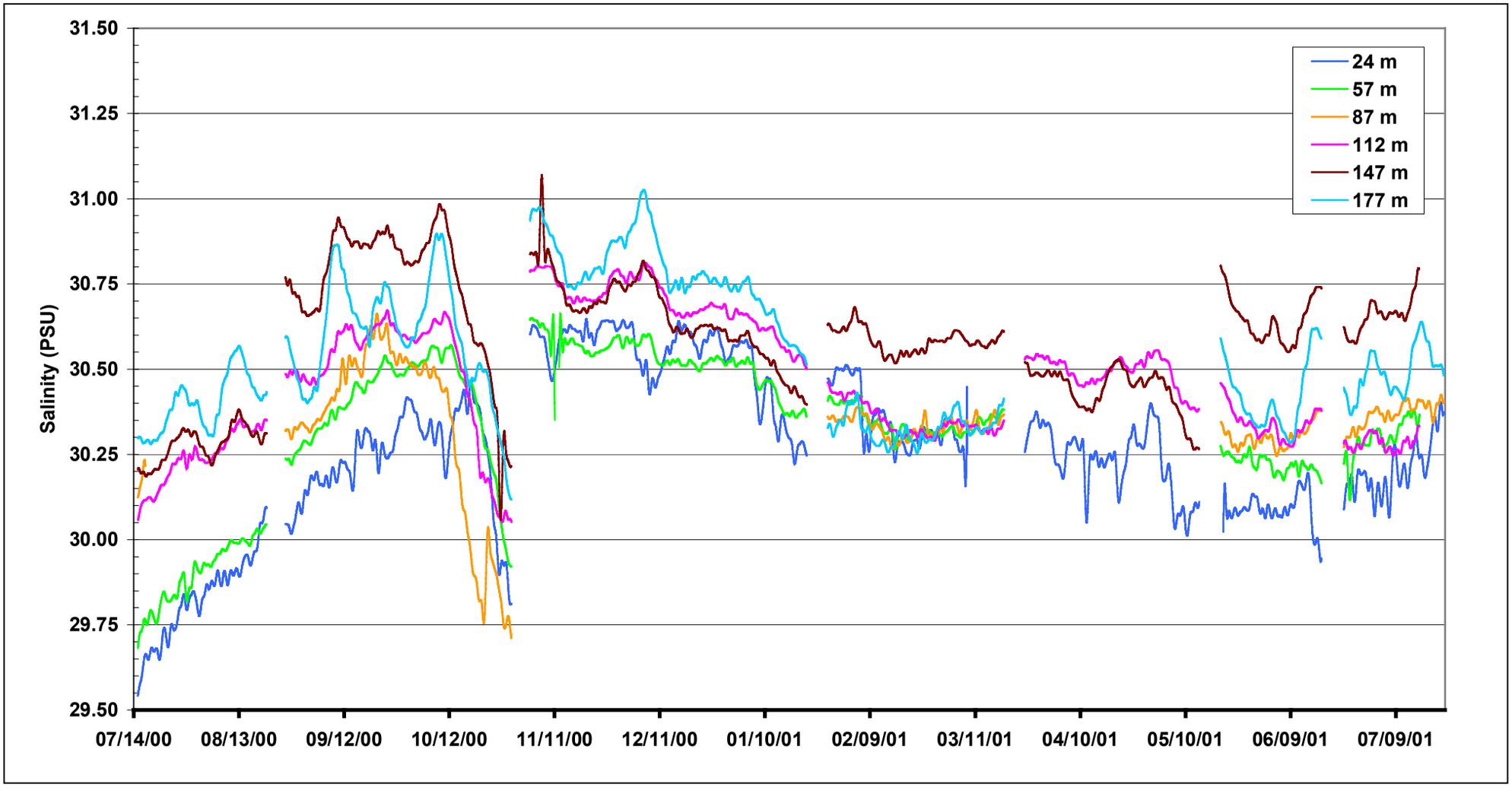
Mean square displacement for drogue Release I (blue) and Release K (green). Dashed lines indicate the rates used to estimate dispersion coefficients (Release I, Release K).

Figure 81. **Yearlong temperatures: Main Basin**



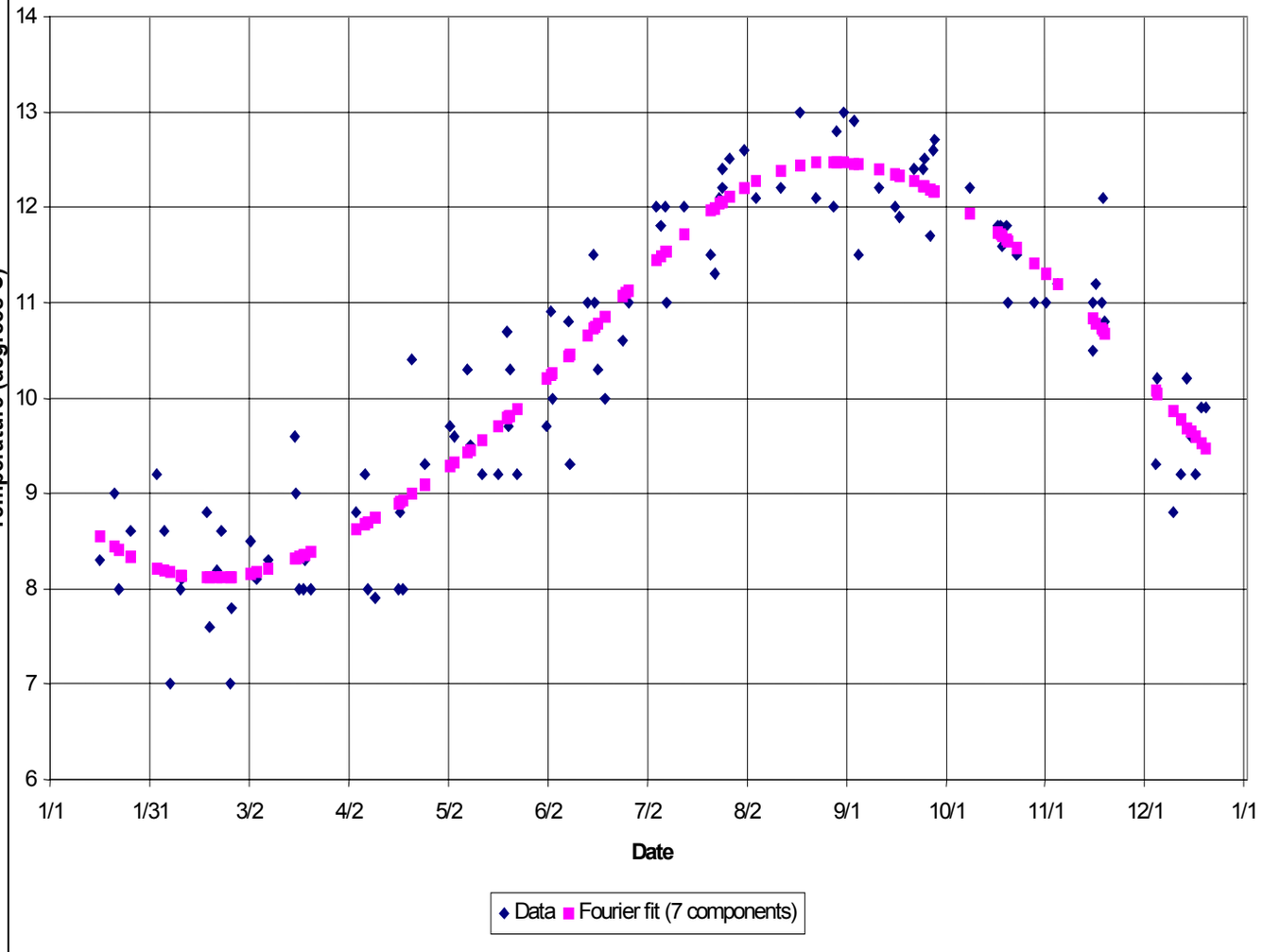
Temperature at the Aanderaa mooring in the Main Basin.

Figure 82. **Yearlong salinity: Main Basin**



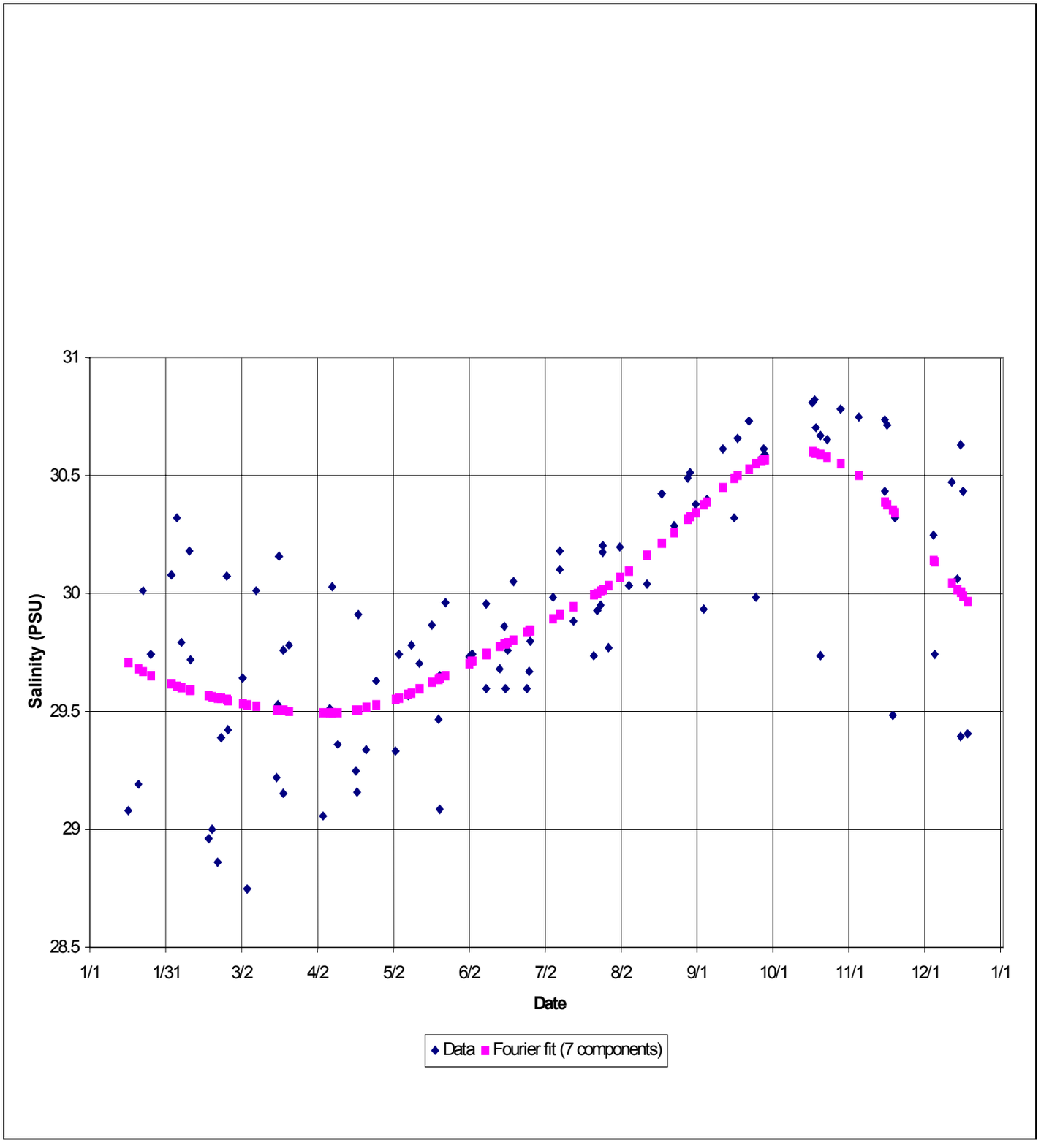
Salinity at the Aanderaa mooring in the Main Basin.

Figure 83. **Temperature, Point Jefferson: 100 m**



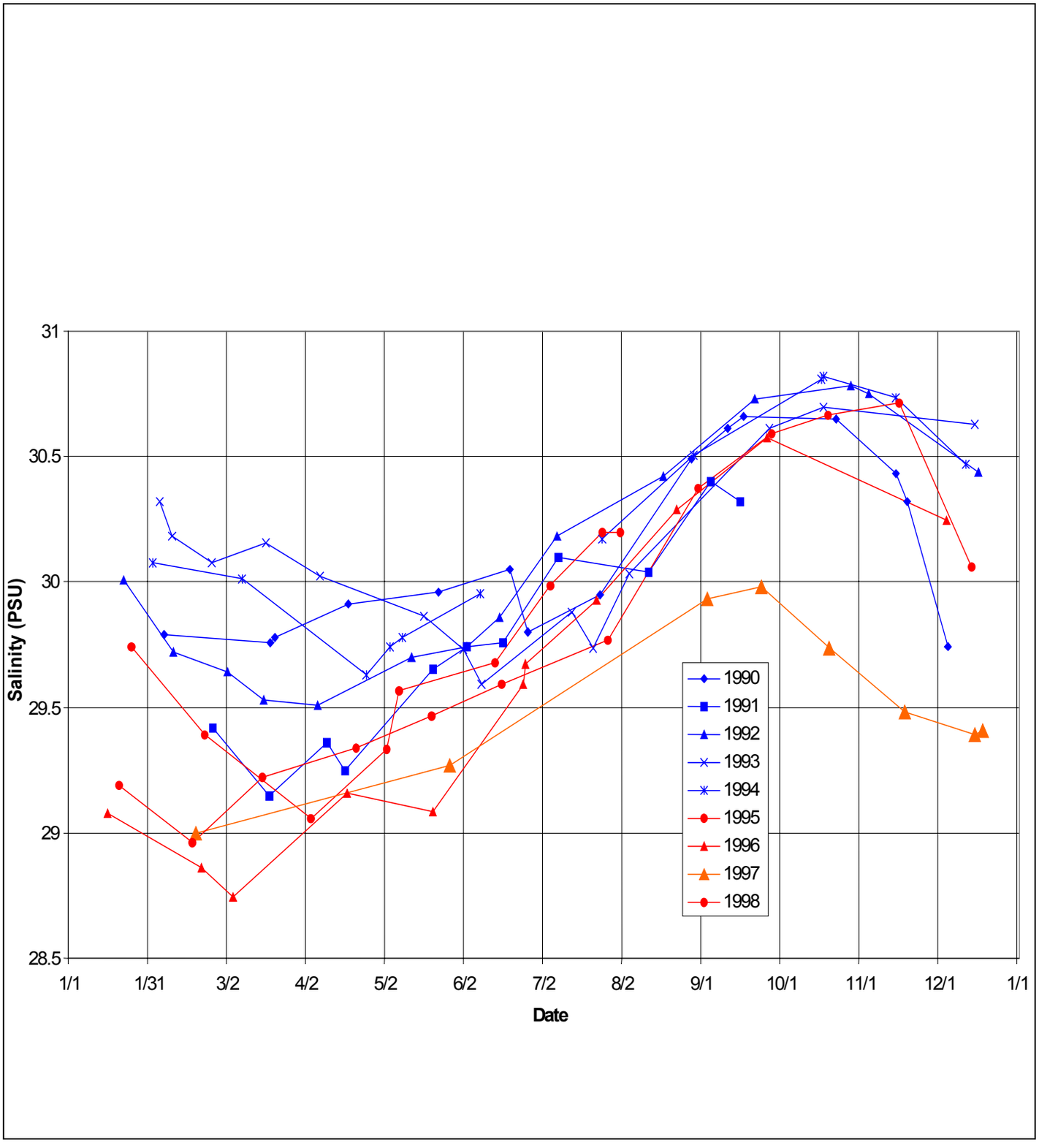
Composite of temperature data (blue) and canonical seasonal cycle with a seven-component Fourier fit (pink) at KSBP01, Point Jefferson, 100 m.

Figure 84. **Salinity, Point Jefferson: 100 m**



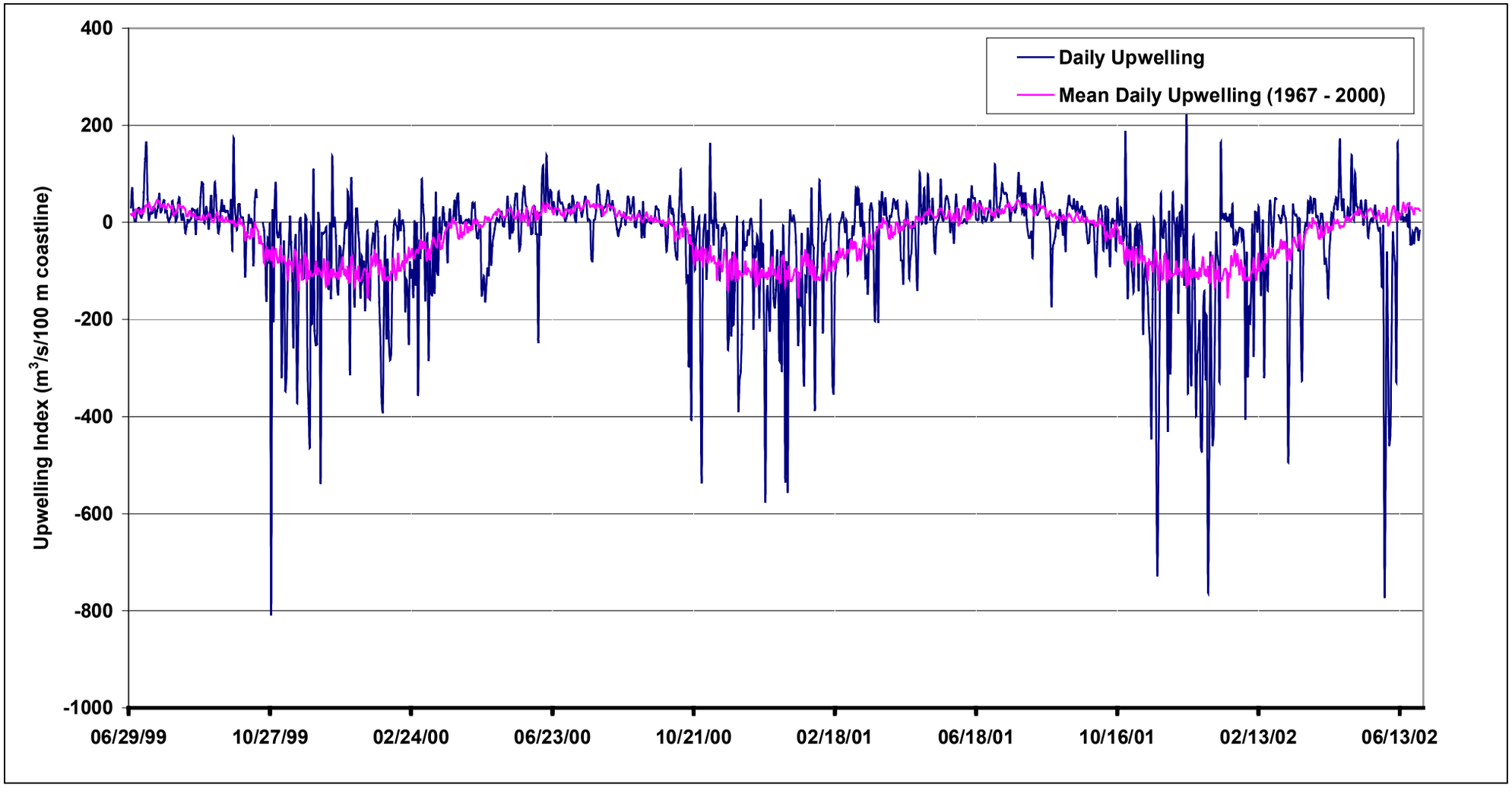
Composite of salinity data (blue) and canonical seasonal cycle with a seven-component Fourier fit (pink) at KSBP01, Point Jefferson, 100 m.

Figure 85. **Salinity by years, Point Jefferson: 100 m**



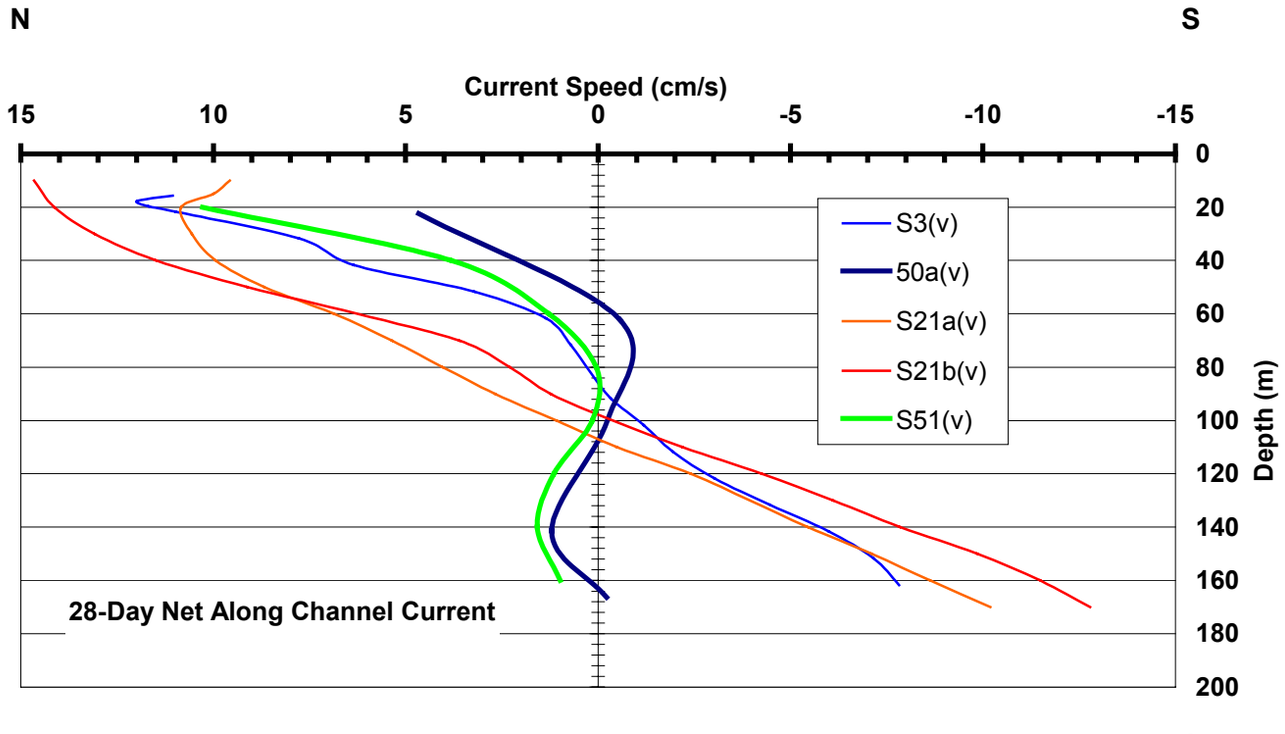
Salinity composite for individual years.

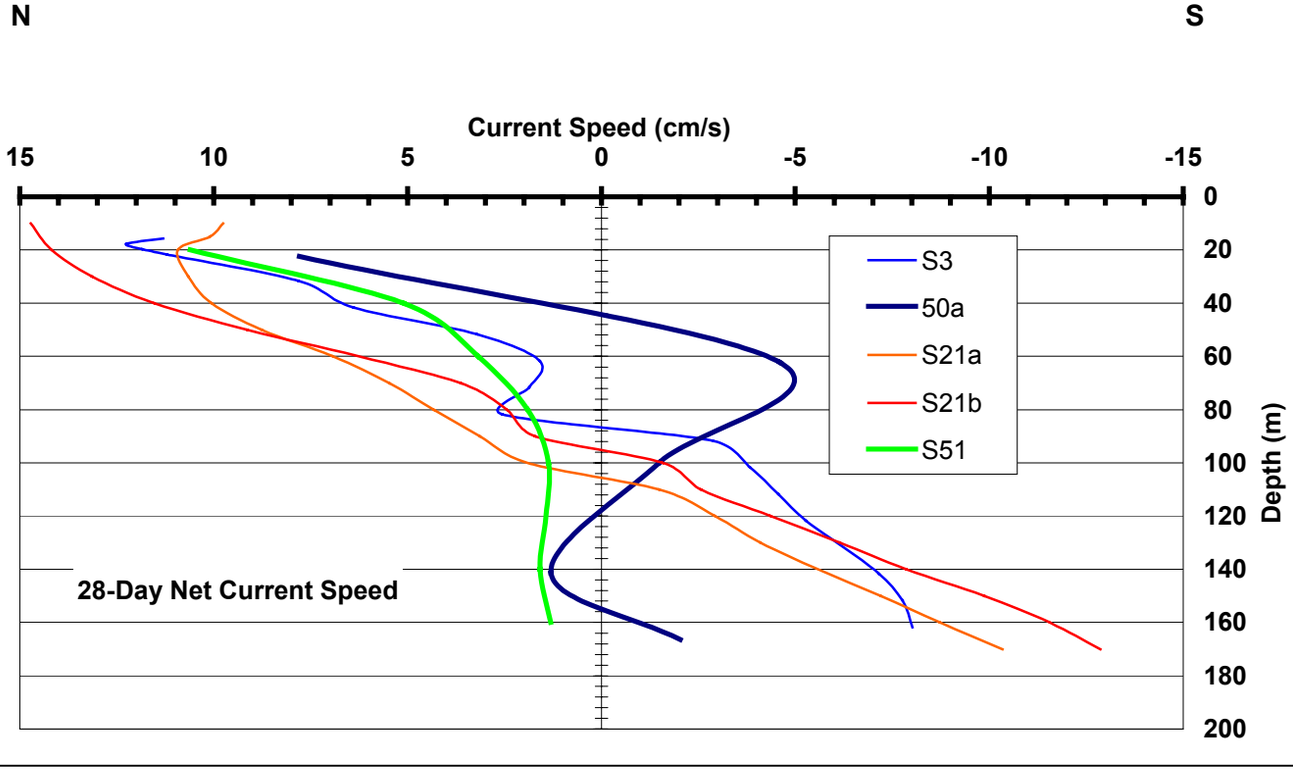
Figure 86. **Coastal upwelling index**



Upwelling index off the Washington coast (Neah Bay; 48°N), and the long-term average 1967-2000. From NOAA data at http://www.pfeg.noaa.gov/products/PFEL/modeled/indices/upwelling/NA/upwell_menu_NA.html.

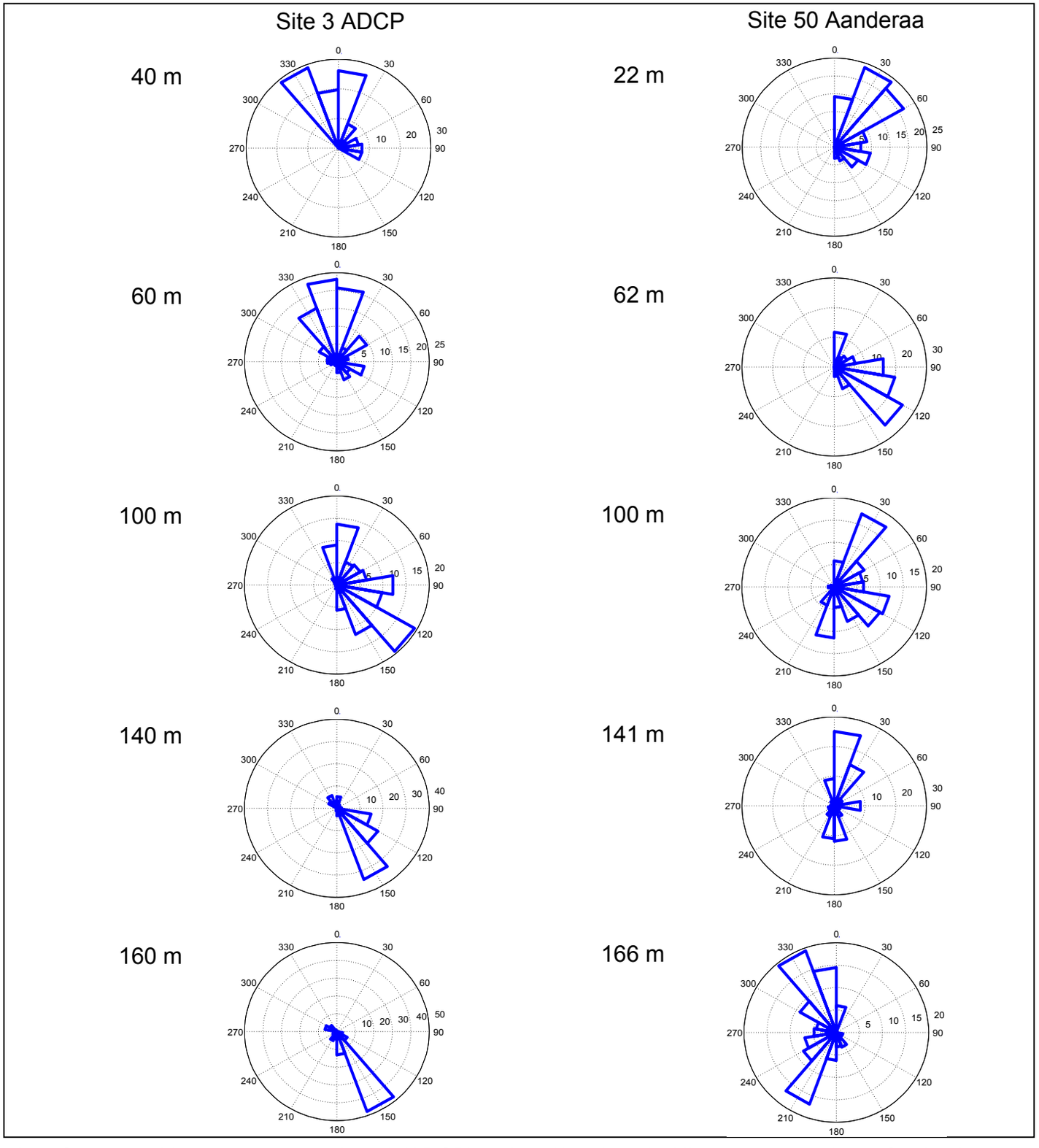
Figure 87. **Profiles of current variability**





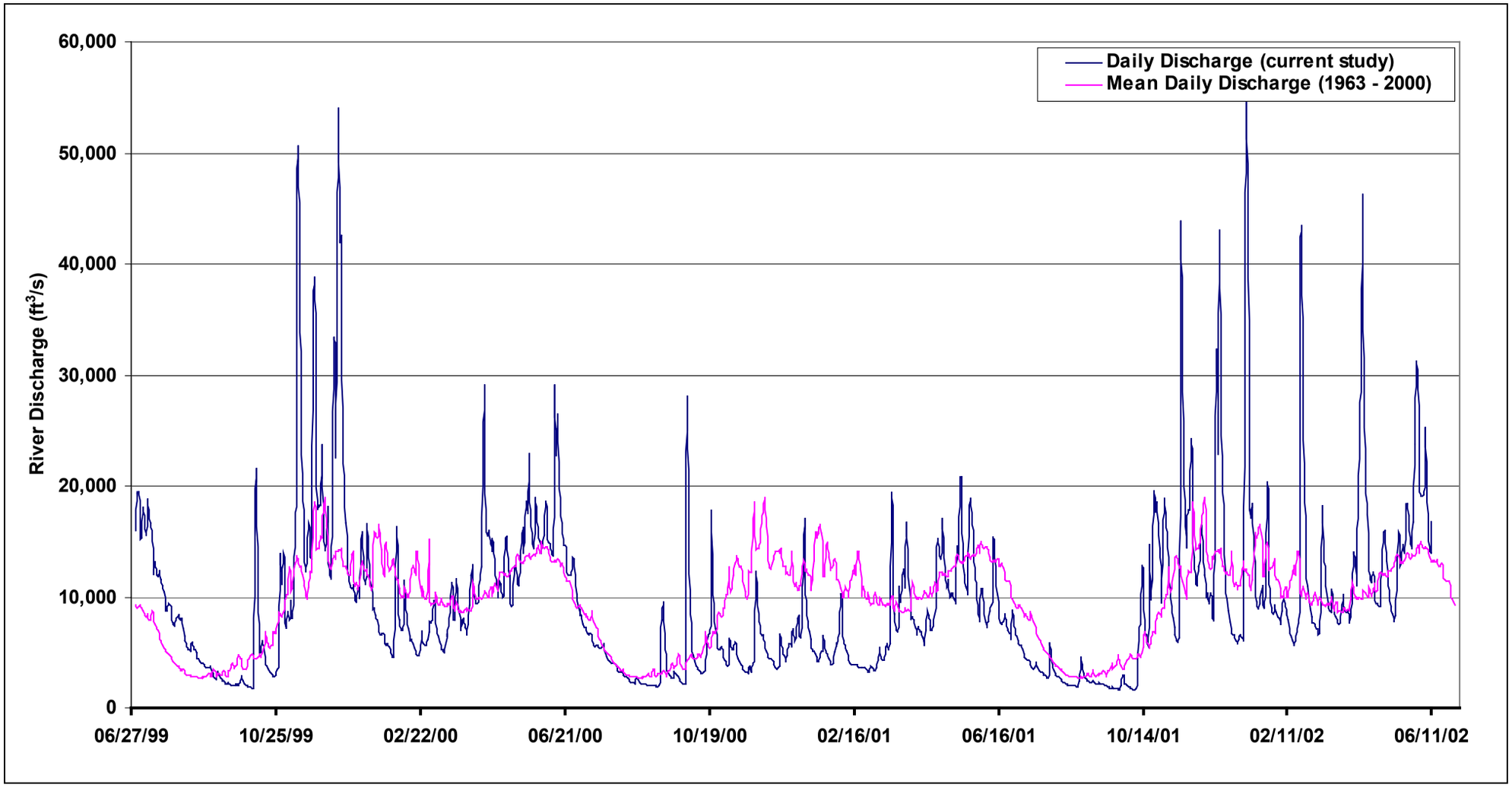
Upper panel: Net north-south 28-day current (total vector speed) at moorings 3, 21, 50, 51. Lower panel: Net north-south 28-day average currents at moorings 3, 21, 50, 51. Dates of the profiles are in Table 6. Different 28-day averages are denoted by a, b.

Figure 88. **Variability of low frequency currents**



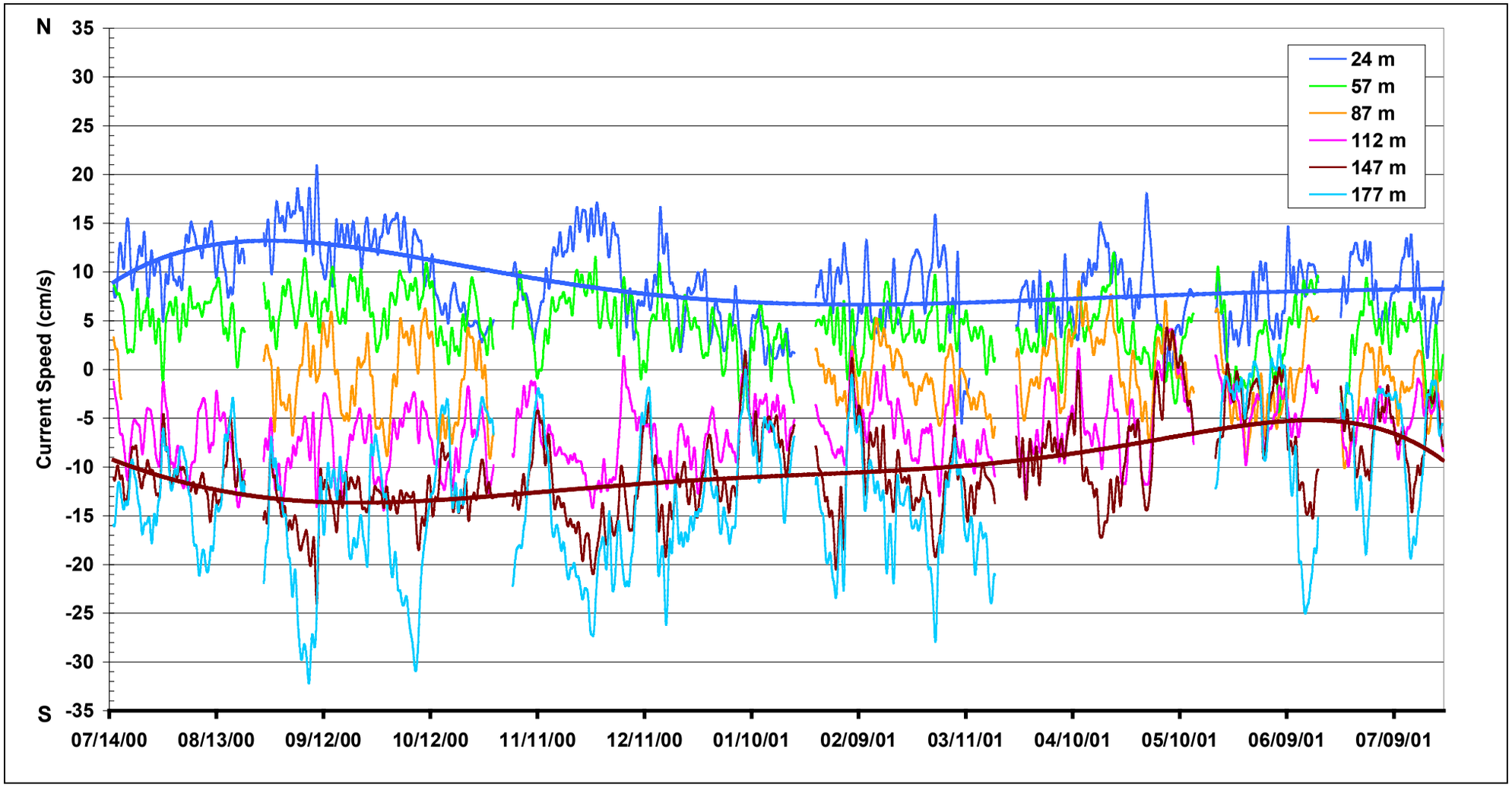
Low frequency histograms at moorings 3 (ADCP) and 50 (Aanderaa). Histograms are shown for depths nearest the Aanderaa depths.

Figure 89. **Snohomish River discharge**



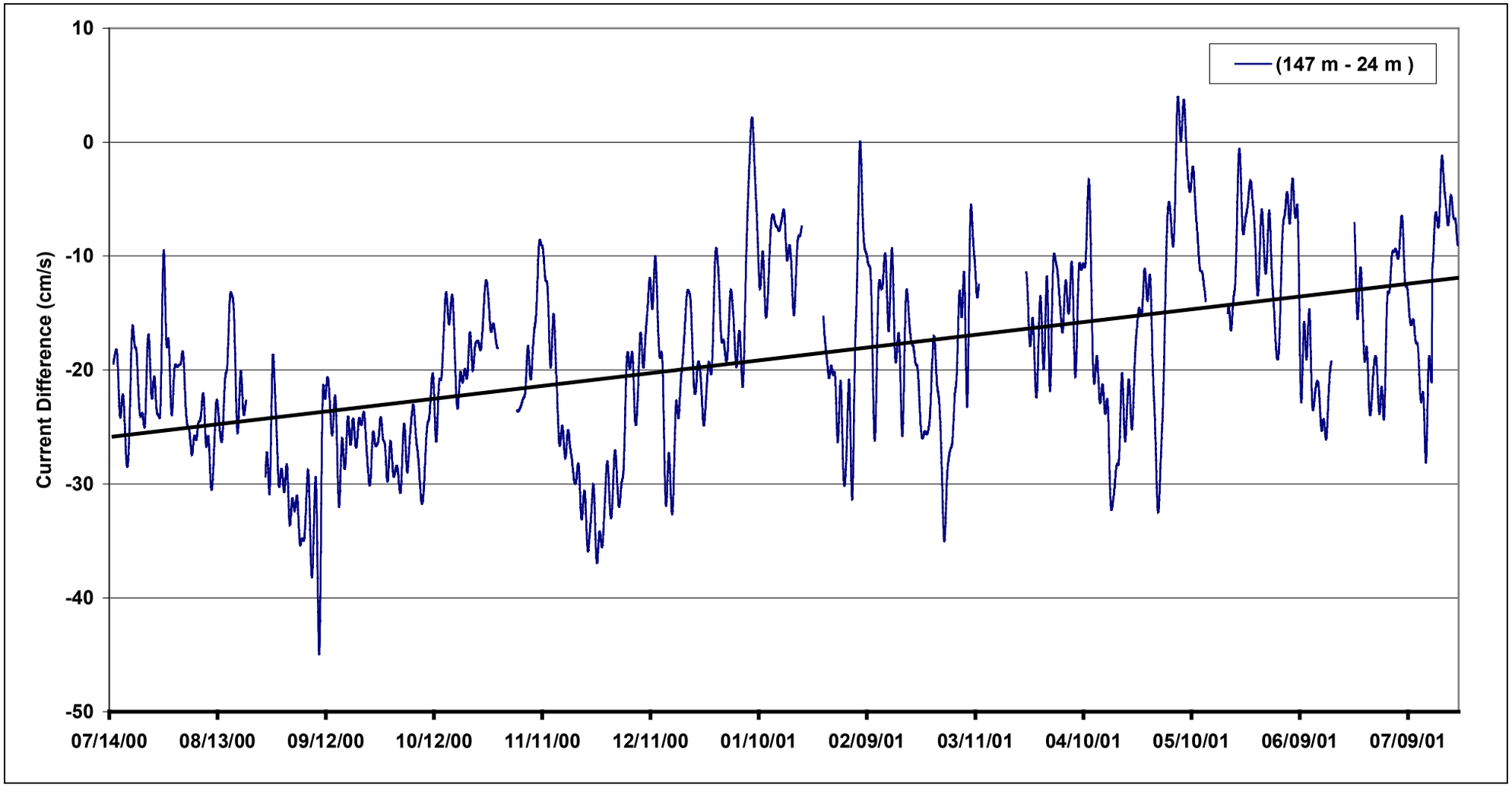
Snohomish River discharge (at Monroe), May 1999 through September 2002, and the long-term average discharge 1963 through 2000. Note the low river flows during the drought interval from September 2000 through September 2001, the second driest year on record after the winter of 1976-77. From USGS provisional data web site.

Figure 90. **Yearlong currents: Main Basin**



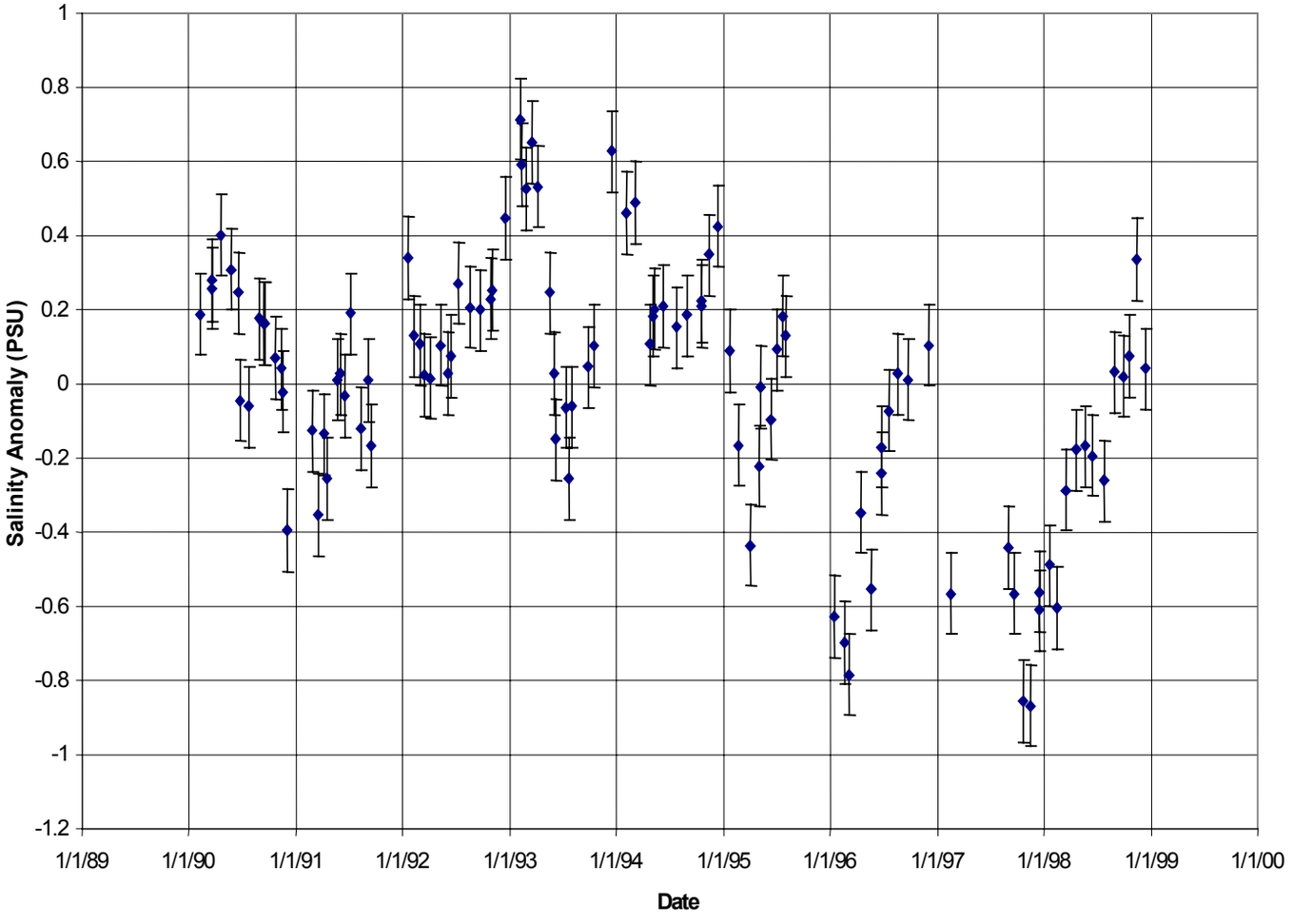
North-south currents at the Aanderaa mooring in the Main Basin. Smooth lines are 6th order polynomial fits to the currents at 24 and 177 m.

Figure 91. **Yearlong vertical current difference: Main Basin**



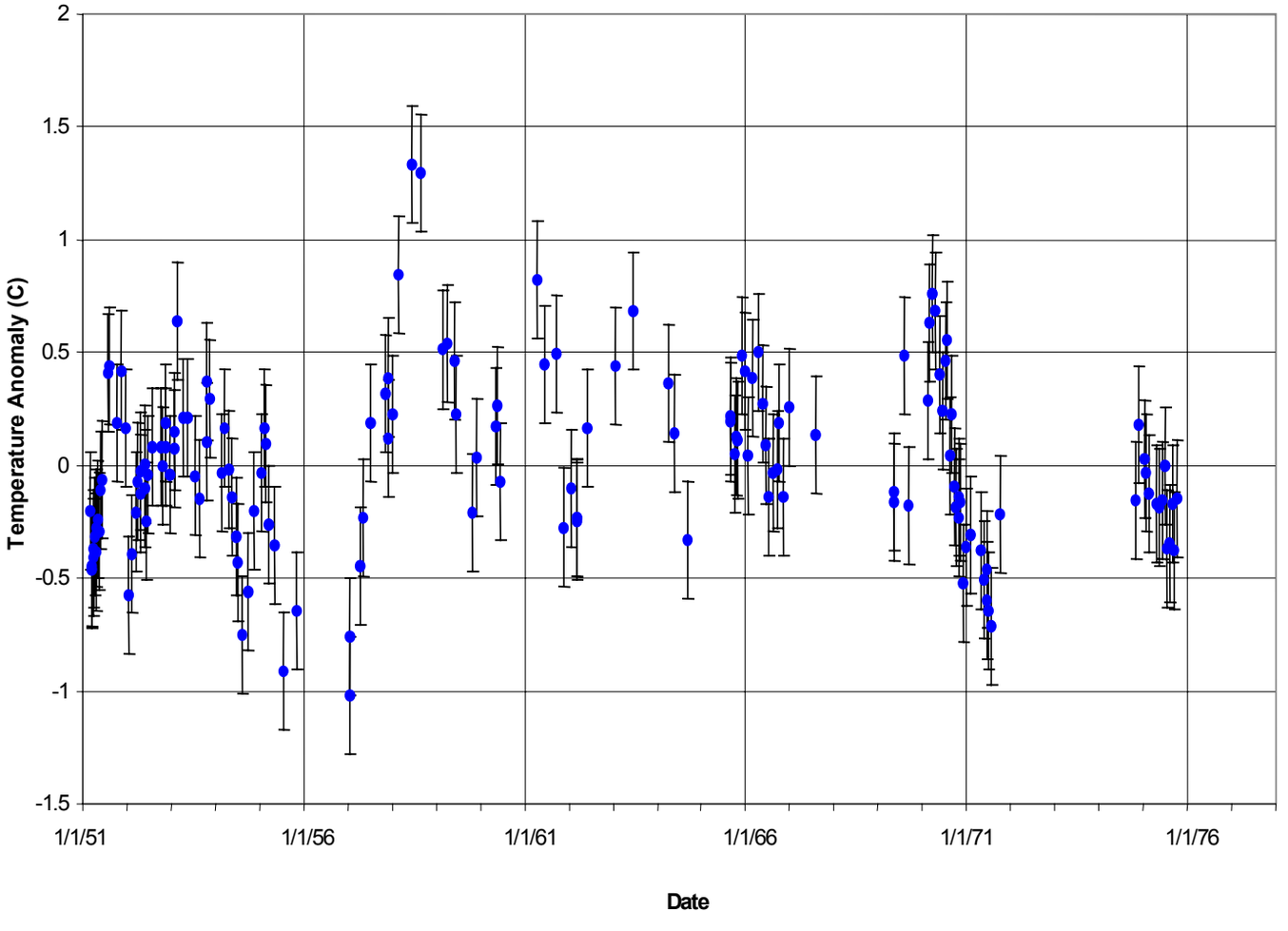
Current differences between 24 and 177 m at the Aanderaa mooring in the Main Basin. Straight line is least-squares best fit.

Figure 92. **Salinity anomaly, Point Jefferson: 100 m**



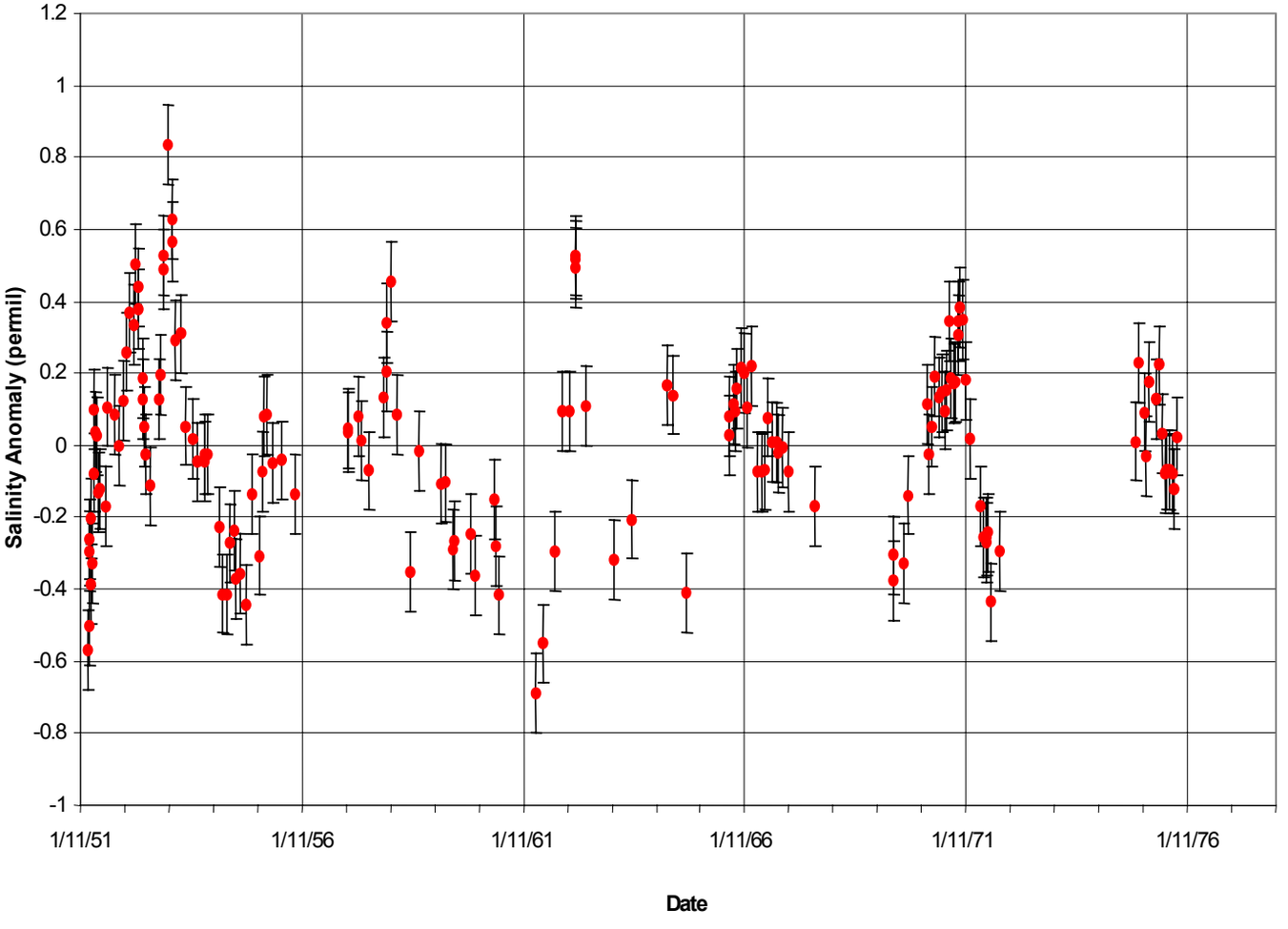
Departure from the canonical salinity cycle. Uncertainty limits are estimated from NOAA MESA01 mooring data (Cannon and Laird, 1978).

Figure 93. **Temperature anomalies, 1951-75, Point Jefferson: 100**



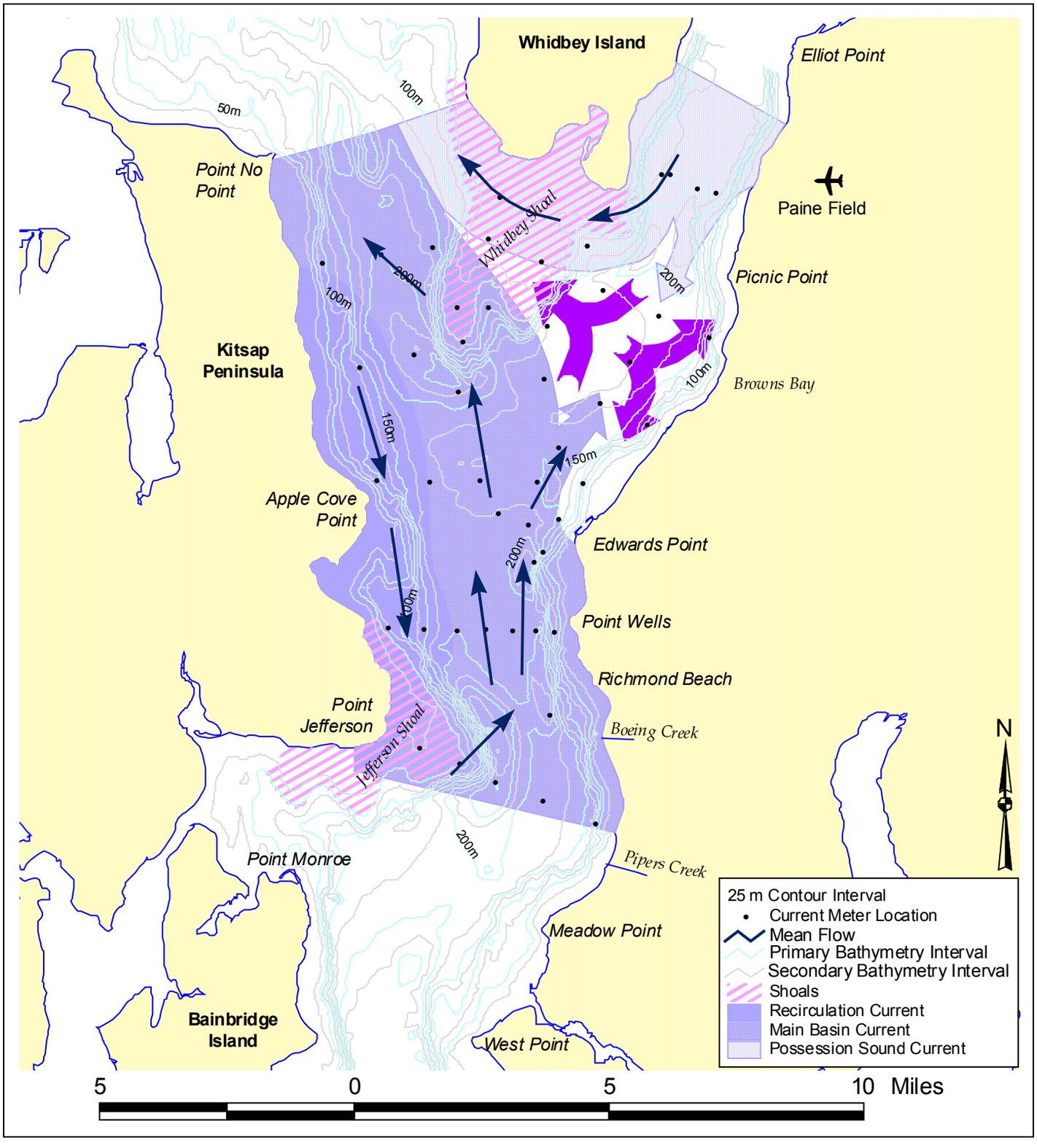
Departure from canonical seasonal cycle for temperature for years 1951 through 1975. Same uncertainty limits as for KSBP01 time series.

Figure 94. **Salinity anomalies, 1951-75, Point Jefferson: 100**



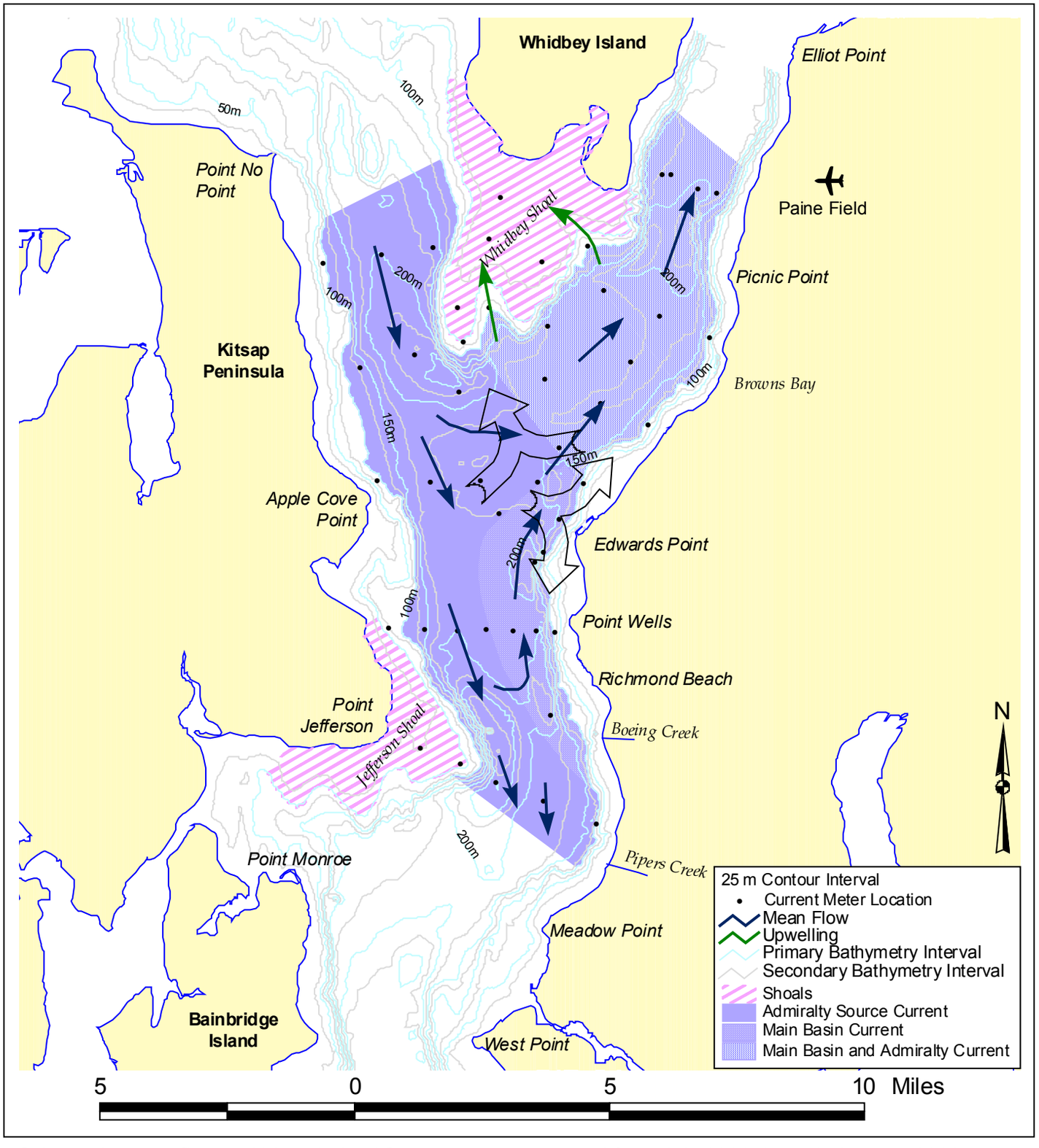
Departure from canonical seasonal cycle for salinity for years 1951 through 1975. Same uncertainty limits as for KSBP01 time series.

Figure 95. **Mean flow schematic: near surface**



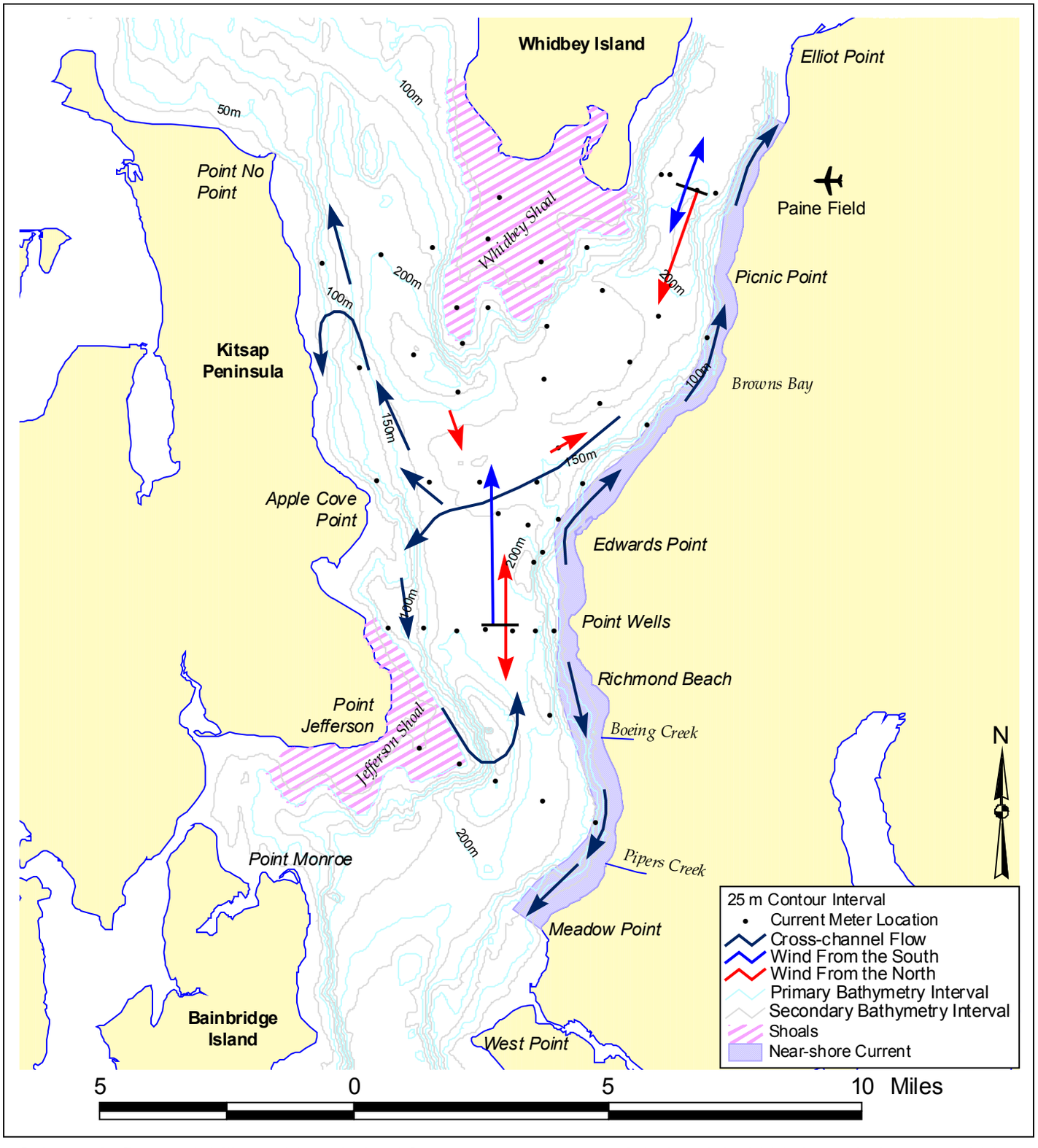
Schematic mean flow at 20 m derived from currents measured from July 2000 through January 2002. Shaded regions and arrows denote major current patterns.

Figure 96. **Mean flow schematic: mid depth**



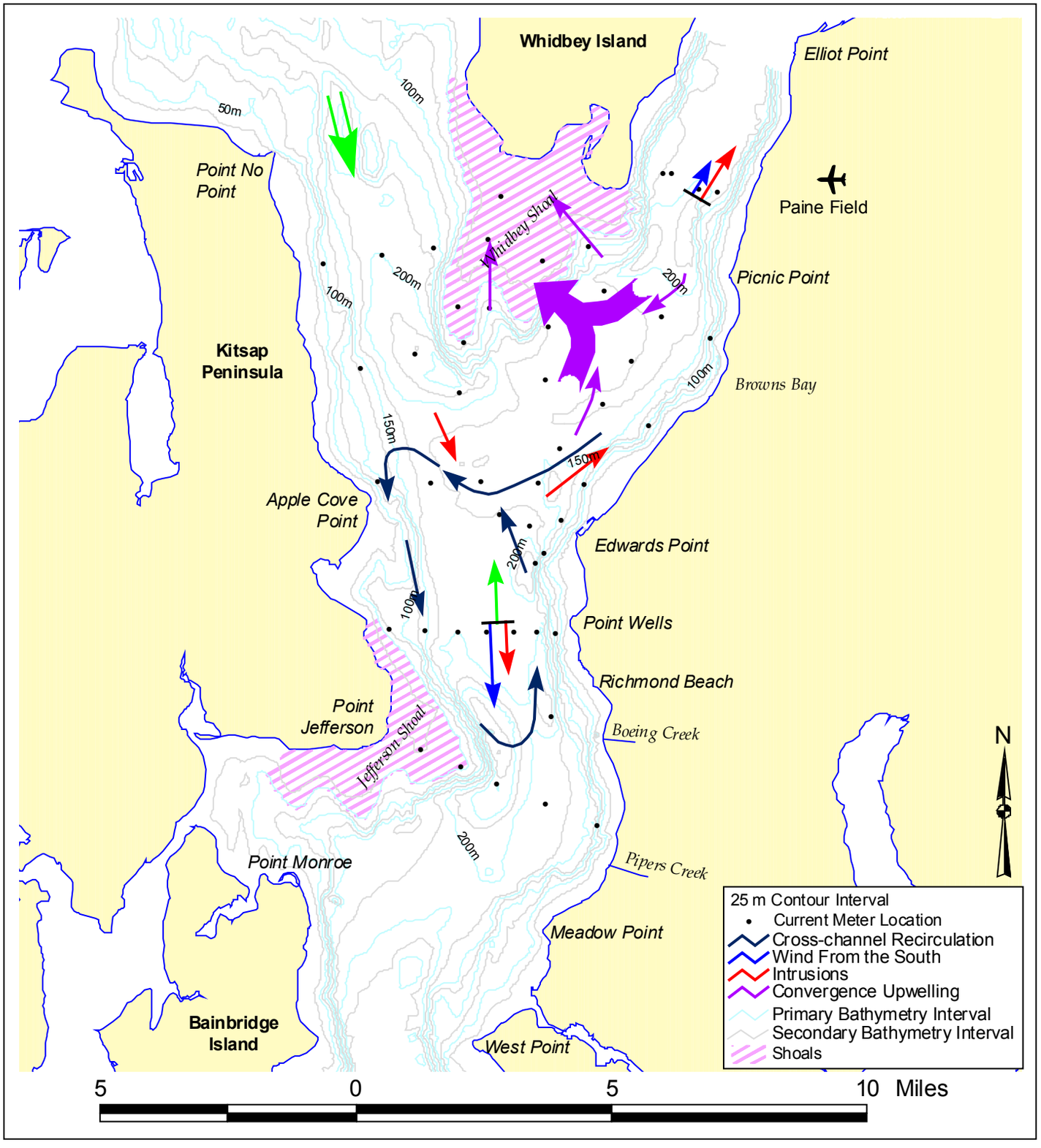
Schematic mean flow at 100 m derived from currents measured from July 2000 through January 2002. Shaded regions and arrows denote major current patterns.

Figure 97. **Flow variability schematic: near surface**



Schematic flow variability at 20 m derived from currents measured during July 2000 through January 2002. Arrows denote major current patterns.

Figure 98. **Flow variability schematic: mid depth**



Schematic flow variability at 100 m derived from currents measured during July 2000 through January 2002. Arrows denote major current patterns.